

**METHOD, SYSTEM AND PROGRAM PRODUCT THAT UTILIZE A
HIERARCHICAL CONCEPTUAL FRAMEWORK TO MODEL AN
ENVIRONMENT CONTAINING A COLLECTION OF ITEMS**

5

CROSS-REFERENCE

SubAI 7
The present application is a continuation-in-part of U.S. Patent Application No. 09/702,184, filed on October 31, 2000, and entitled "System and Method to Automate Equipment Placement at Remote Sites." The present application is also related to the following U.S. patents, which are assigned to the assignee of the present application and incorporated herein by reference in their entireties: U.S. Patent Nos. 5,930,779, 5,991,759, 6,098,050, 6,169,987, and 6,023,699.

10

15

BACKGROUND OF THE INVENTION

1. Technical Field:

The present invention relates in general to data processing and in particular to a data processing system, method and program product that utilize a hierarchical conceptual framework to model an environment containing a collection of items.

20

2. Description of the Related Art:

Affordable technology, and in particular the availability of powerful, commercially affordable computer systems and associated data storage, has revolutionized business practices and management over the preceding decades. This revolution has affected all aspects of business, including data management in accounting, payroll, and human resources systems; business communication; business

25

30

forecasting and market modeling; warehouse, supply chain and product distribution management; and facility management.

5 The above-referenced patents represent a significant advance in facility management by disclosing a software tool (referred to herein as SiteVu) that can be utilized not only for general site planning of an organization's physical plant, but also to specifically record, maintain and view the placement of, and information of interest associated with, specific physical assets within the physical plant. SiteVu provides these features through a hierarchical conceptual framework that enables a user to intuitively create and maintain a detailed data model of an organization's physical assets.

10 Although SiteVu has definite applicability to the design and management of telecommunications field sites as discussed above, the present invention recognizes that its use is by no means limited to such applications. Rather, the hierarchical conceptual framework employed by SiteVu is broadly applicable to the creation, display and management of a collection of items in a modeled environment.

SUMMARY OF THE INVENTION

The present invention provides a method, system and program product for modeling an environment containing a collection of items. In accordance with a preferred embodiment of the method of the present invention, an environmental hierarchy describing a model environment, a product catalog containing data describing a plurality of items that may be utilized to populate the modeled environment, and a configuration library containing data describing a spatial relationship between first and second items among the plurality of items in the product catalog are created. The modeled environment is then populated by storing, in a database, data representative of the spatial relationship between the environmental hierarchy and a collection of items including the first item.

5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235
240
245
250
255
260
265
270
275
280
285
290
295
300
305
310
315
320
325
330
335
340
345
350
355
360
365
370
375
380
385
390
395
400
405
410
415
420
425
430
435
440
445
450
455
460
465
470
475
480
485
490
495
500
505
510
515
520
525
530
535
540
545
550
555
560
565
570
575
580
585
590
595
600
605
610
615
620
625
630
635
640
645
650
655
660
665
670
675
680
685
690
695
700
705
710
715
720
725
730
735
740
745
750
755
760
765
770
775
780
785
790
795
800
805
810
815
820
825
830
835
840
845
850
855
860
865
870
875
880
885
890
895
900
905
910
915
920
925
930
935
940
945
950
955
960
965
970
975
980
985
990
995

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIG. 1A is a block diagram depicting an operational environment according to a preferred embodiment of the present invention;

FIGS. 1B-1G are block diagrams depicting various functional components according to a preferred embodiment of the present invention;

FIG. 1H is a block diagram depicting the components of a database according to a preferred embodiment of the present invention;

FIG. 2 is a block diagram depicting a rack, shelves and modules forming a portion of an item hierarchy in one application of the present invention;

FIG. 3 is a block diagram depicting a graphical representation of a site hierarchy in one application of the present invention;

FIGS. 4A and 4B together form a flowchart of a process for creating a configured shelf, according to a preferred embodiment of the present invention;

FIG. 5 is a flowchart depicting a process that can be used to create a configured rack in the item hierarchy of a telecommunications environment, according to a preferred embodiment of the present invention;

FIG. 6 is a flowchart depicting a process that can be used to create components in the product catalog, according to a preferred embodiment of the present invention;

5

FIG. 7 is a flowchart depicting a process that can be used to create an environmental hierarchy, according to a preferred embodiment of the present invention;

10

FIG. 8 is a flowchart depicting a process that can be used for uniting an item from the product catalog with a level of the environmental hierarchy to create a footprint, according to a preferred embodiment of the present invention;

15

FIG. 9 is a block diagram of a computer useful for implementing components of the present invention;

20

FIGS. 10A-10N are block diagrams illustrating a plurality of database tables that can be used to implement the database depicted in FIG. 1A, according to a preferred embodiment of the present invention;

In the figures, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements. The figure in which an element first appears is indicated by the leftmost digit(s) in the reference number.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The present invention is directed to a data processing system, method, and program product that allow a user to construct a conceptual hierarchical framework representing a virtual or physical environment and then populate the environment with a collection of items. The present invention permits users to graphically and intuitively view and manipulate various subsets of the environment's space as well as items placed within the modeled environment. The user is also able to create and store tabular information describing the configuration of the graphical objects and the items represented by the graphical objects. The detailed description is arranged as follows:

Section I explains an exemplary embodiment of the present invention;

Section II provides an operational overview of an exemplary embodiment of the present invention;

Section III presents the architecture of the SiteVu tool suite, including an overview of the database and the software components of SiteVu;

Section IV describes an exemplary item hierarchy (i.e., an equipment rack in a telecommunications application);

Section V describes an exemplary environmental hierarchy (i.e., a site hierarchy);

Section VI describes the creation of a configured rack, including creation of a product catalog component (e.g., module, shelf or rail), creation of a shelf configuration, and the addition of modules to the shelf;

Section VII discusses the site hierarchy database;

Section VIII describes the creation of graphical objects representing components of the site hierarchy;

Section IX describes an exemplary implementation of the present invention in a computer system;

Section X provides a detailed discussion of an exemplary site hierarchy;

Section XI describes a number of additional exemplary applications of the present invention; and
Section XII is a brief conclusion.

5

I. Exemplary Embodiment

The present invention is described herein with reference to an exemplary embodiment in which a software application suite named SiteVu is executed by a data processing system having an input device and display to provide all of the features of the present invention. The description in such terms is provided for convenience only and is not intended to limit the present invention. In addition, the present invention is principally described herein as applied to the telecommunications industry. However, as made clear by the range of exemplary applications set forth in Section XI, the present invention is not limited to application within the telecommunications industry, but is instead applicable to other industries and environments. In fact, after reading the following description, other embodiments and applications of the present invention will become apparent to persons skilled in the relevant art(s).

10

15

20

II. Operational Environment

FIG. 1A is a block diagram depicting a typical operational environment according to a preferred embodiment of the present invention. A network **102** is depicted in the center of **FIG. 1A**. Network **102** represents any type of computer and/or telecommunications network or combination thereof, which can be used to couple a plurality of workstations **104** with a relational database **108**. In this example, each workstation **104** is a general-purpose computer system that executes software (referred to herein as SiteVu) that causes computer systems **104** to perform the functions described herein.

25

30

In some embodiments of the present invention, network **102** can be a company wide intranet. In other embodiments, local area networks (LANs), or wide area networks (WANs), such as multiple LANs linked together with bridges, routers

or the like, can be used as network 102. In addition, network 102 can include switched networks and other forms of common carrier transmission lines and equipment that can link remote computers, such as the remote workstations 104, to relational database 108.

5

Also depicted in FIG. 1A are file server log 103 and a storage device 101 storing architectural drawings. In a preferred embodiment, each computer system 104 executes software that performs computer-aided drafting and design (CADD) functions. As described below, the CADD software is controlled by the SiteVu program in a preferred embodiment of the present invention. In this example, architectural drawings may be stored on local storage devices in each of workstations 104 or in a central file server, such as file server 103. This aspect of the present invention is described below.

10

15

In this example, relational database 108 is coupled to a database server 106. Relational database 108 can be implemented, for example, with an Oracle relational database, supplied by Oracle Corporation. Further, Microsoft Windows® (available from Microsoft Corporation of Redmond, Washington) can be used as the operating system for computer systems 104 used to execute the SiteVu suite (including the SiteVu placement tool) and the CADD programs. Finally, in a preferred embodiment, the CADD program used is Microstation CADD, manufactured by Bentley Systems, Inc.

20

III. SiteVu Architecture

25

Figs. 1B-1H depict an example of an architecture of the SiteVu program and associated database, according to a preferred embodiment of the present invention. Specifically, FIG. 1H illustrates logical database components, and FIGS. 1B-1G depict exemplary SiteVu components and their associated inputs and outputs.

30

A. Logical Database Components

Referring first to FIG. 1H, the logical components of database 108 are depicted according to a preferred embodiment of the present invention. Specifically,

in this example, database **108** comprises a site hierarchy repository **124**; a product catalog **126**; a configuration library **128**; a placement library **130**; user security **132**; pick lists **134**; connections **136**; and power tables **138**. A more detailed description of a database **108** for telecommunications applications is subsequently described below in section VIII with reference to **Figs. 10A-10N**.

B. SiteVu Components

Referring now to **Figs. 1B-1G** exemplary SiteVu components and their associated inputs and outputs are illustrated.

1. Overview of the Components

As indicated in **FIG. 1B**, SiteVu central database **108** is preferably a relational database management system. The SiteVu tool (**FIG. 1B**) comprises the following components: SiteVu Power Pages (SVPP) **110**; SiteVu Rackface tool (SVRF) **112**; SiteVu Administrative tool (SVAD) **114**; SiteVu Placement tool (SVPL) **116**, and SiteVu Report Generator (SVRP) **119**.

2. Power Page Tool

As shown in **FIG. 1C**, power page **110** reads data from and stores data in database **108**. Power page **110** provides power estimates for remote field sites. In a preferred embodiment, a web browser **111** is used to input data into power page **110** from workstation **104** and to output data from power page **110** to workstation **104**.

3. The Rackface Tool

As depicted in **FIG. 1D**, rackface tool **112** reads data from and stores data in database **108**. Rackface tool **112** is used to define components for product catalog **126**. Further, rackface tool **112** is used to define configured shelves using empty shelves and modules from product catalog **126** and store configured shelves in the configuration library **128**. In addition, rackface tool **112** is used to define configured racks from rails and configured shelves from the product catalog **126** and configuration library **128**, respectively. Such configured racks (also referred to as racks), are stored in configuration library **128**.

In addition, rackface tool 112 is used to operate on footprints. As stated, footprints are racks that have been placed in remote sites via placement tool 116 (described below). Specifically, in a preferred embodiment, rackface tool 112 is used to display information about footprints and to replace one footprint with another footprint, as described below.

In a preferred embodiment, rackface tool 112 is implemented using the Microsoft Windows operating system. Thus, Windows Application Programming Interface 113 is used to implement the functions provided by the rackface tool 112 on a workstation 104.

FIG. 1D depicts various types of data used by rackface tool 112, according to a preferred embodiment of the present invention. As indicated by the data-in list 120, rackface tool 112 reads pick lists 134 from database 108. As described in further detail below, a pick list is a database table that comprises a list of valid values for particular data fields within database 108. Preferably, pick list tables are used during a data entry process to provide users with a drop-down list box, or the like, comprising textual representations of predefined values that can be specified for particular data fields. Note that the term “pick list” is used herein to describe a pick list table in database 108. However, the term is also used herein to describe the drop-down list box that is associated with a pick list table and used during a data entry process, as described above.

In addition, rackface tool 112 reads data from the product catalog 126 to create shelf configurations that are stored in the configuration library 128. Further, configured shelf data from configuration library 128 is used to create rack configurations that are also stored in configuration library 128. Site hierarchy data are read from the site hierarchy repository 124 and used to replace generic footprints with manufacturer-specific footprints. Further, placement data are read from the placement library and used to display footprint information and replace generic and manufacturer-specific footprints, as described below.

User and security data 132 are read by rackface tool 112 to determine access

rights and the like for particular users. In addition, placement data are read from the placement library 130 when rackface tool 112 replaces generic footprints, as described below.

5 Examples of data output from rackface tool 112, as indicated by data-out list 122, include product catalog data, configured shelves data and configured rack data. For example, rackface tool 112 is used to create components for product catalog 126. An example of a process that can be used to create components in product catalog 126 is described below with reference to FIG. 6.

10 Similarly, rackface tool 112 is used to create entries in the configuration library 128. An example of a process that can be used to create data entries for configuration library 128 is described below with reference to FIGS. 4A, 4B and 6.

15 Another example of data output from rackface tool 112 includes data used to update placement library 130. For example, placement library 130 is updated when a generic footprint is replaced with a manufacturer-specific footprint, as described below.

20 4. Administrative Tool

As shown in FIG. 1E, administrative tool 114 reads data from and stores data in database 108. Administrative tool 114 is used to create and update pick lists 134, user security data 132, and site hierarchy repository 124. In a preferred embodiment, administrative tool 114 is implemented using the Windows operating system. Thus,
25 Windows Application Programming Interface 115 is used to implement the functions provided by administration tool 114 on a workstation 104.

FIG. 1E depicts various types of data used by administrative tool 114 according to a preferred embodiment of the present invention. As indicated by
30 data-in list 120, administrative tool 114 reads pick lists 114 and user security data 132 from database 108.

As indicated by data-out list 126, administrative tool 114 creates and updates

pick lists 134 and user security data 132. In addition, this tool can be used to create part of the site hierarchy that is stored in site hierarchy repository 124, as described below. Specifically, the sites, buildings (or structures) and the non-graphical portion of the floor level hierarchies, if any, can be created utilizing administrative tool 114.

5

5. Placement Tool

As indicated by FIG. 1F, placement tool 116 reads data from and stores data to database 108. Specifically, placement tool 116 can be used to create footprints (i.e., equipment placed on the floor space) by placing racks in remote sites. Such data are stored in placement library 130. In a preferred embodiment, placement tool 116 is also implemented using the Windows operating system. In addition, graphics are provided by a CADD program, such as Microstation CADD 117, as previously described.

10

15

FIG. 1F depicts the various types of data used by placement tool 116, according to a preferred embodiment of the present invention. As indicated by data-in list 128, placement tool reads pick lists 134, user and security data 132, site hierarchy data 124, placement data 130, configured rack data 128, and power plant definition data 138 from database 108.

20

As indicated by data-out list 130, placement tool 116 uses a site hierarchy (e.g., from a site down to a floor) established by administrative tool 114 to create graphical and database representations of remote sites, buildings, floor, zones, rows (specifically row segments), and footprints. Placement tool 116 can also be used to update both the graphical representations and the database data associated with these objects. Therefore, the tool can be used to update site hierarchy data 124, configuration data 128, pick list data 134, and placement data 130.

25

6. Report Generator

As indicated in FIG. 1G, report generator 119 reads data from database 108 to generate reports. In the illustrated embodiment, report generator 119 is implemented using Microsoft Access 121. Reports can be printed on a printer 123.

30

FIG. 1F

IV. Equipment Rack

As noted above, in telecommunications applications of SiteVu, network equipment to be managed within remote sites is typically arranged and mounted in equipment racks. **FIG. 2** is an illustration depicting a typical equipment rack **202**. Equipment rack **202** comprises a plurality of shelves **204a-204f** (generally **204**). In this example, shelf **204a** comprises a plurality of vertically positioned slots **208a-208o** (generally **208**). Typically circuit cards, such as circuit card **214**, are installed in slots **208**.

As described below with reference to **Figs. 4A** and **4B**, data related to particular modules that can be used to configure shelves **208**, according to a preferred embodiment of the present invention, are stored in product catalog **126**. For example, circuit card **214** is an example of a type of module that is preferably represented in product catalog **126**. Other examples of modules can be represented in product catalog **126** are workstation **210** and modem **206**. As shown in **FIG. 2**, modules **206**, **210** and **214** belong to the configuration of shelves **208**, according to a preferred embodiment of the present invention.

V. Environmental Hierarchy

FIG. 3 is a block diagram that graphically illustrates an example of an environmental hierarchy (in this case site hierarchy) that can be utilized to represent a virtual or physical environment, as previously described. The site hierarchy shown in **FIG. 3** comprises a floor (e.g., of a building) **302**, three zones **304** within floor **302**, four planning units **306** within various zones **304**, and a plurality of row segments **308** within each planning unit **306**. As previously described, each site hierarchy level shown in **FIG. 3** is preferably represented as a polygonal graphical shape that completely encloses the lower site hierarchy level(s), if any, contained therein.

In the illustrated exemplary embodiment, zones typically represent physical locations in which equipment of a particular class is placed. In a preferred embodiment, racks cannot be placed unless the equipment class of the rack matches

the equipment class of the zone in which the rack is being placed. This restriction can be overridden, however, by a user with "superuser" permissions.

In this example, planning units 306 are specified so that multiple users can define row segments 308, in the same zone 304, at the same time. In a preferred embodiment, database 108 is shared by multiple users. However, in order to maintain data integrity, certain precautions must be taken. In this example, when a user is in the process of defining rows and placing row segments 308, via placement tool 116, as described below, other users are prevented from accessing certain portions of site hierarchy repository 124. In particular, the site hierarchy level immediately above the row level being defined is preferably locked. Because of this locking, planning units 306 are implemented in the site hierarchy between row levels 308 and zone levels 304. As a result, planning unit 306 is locked from other users instead of the zone level 304. In this manner, several users can work simultaneously to define row segments 308 within the same zone 304.

Further, in this example, footprints can only be created in row segments 308. As described below, a physical row in a site may comprise one or more row segments 308. In the simple example shown in FIG. 3, there is a one-to-one correspondence between physical rows and row segments 308. However, a site hierarchy level called a row segment 308 is used in a preferred embodiment of the present invention to prevent users from placing racks in areas that have physical obstructions. For example, suppose a physical obstruction, such as a building support column, is present within a particular row in a field site. In this case, the physical row is represented by two row segments that are placed to avoid the obstruction. In this fashion, since racks can only be placed within row segments 308, a user cannot inadvertently place a rack in the same position as the obstruction.

As noted above, an implementation of the present invention provides a means for defining components, including modules, shelves and rails, which are stored in product catalog 126. Preferably, detailed information pertaining to each component within the product catalog 126 is defined during a data entry process.

VI. Creating Configured Racks From Product Catalog Components

A. Creating a Product Catalog Item

FIG. 6 is a flowchart depicting an example of a data entry process that can be used to create items in product catalog 126 according to a preferred embodiment of the present invention. Specifically, in a preferred embodiment, this process is performed via rackface tool 112 of SiteVu. The process begins with step 602. In step 602, a user selects the component type. In this example, component types include modules, shelves and racks. Once a component type is selected, control passes to step 604. In step 604, the user specifies values for each attribute presented in a predefined list of attributes that are applicable to the selected component type. Preferably, a different predefined list of attributes is presented for each component type. Thus, a particular list of attributes is presented to the user, depending on the type of component selected in step 602. Generally, values for attributes are specified by either typing data directly into data entry fields or by selecting one or more predefined items from a pick list associated with the data attribute. It should also be noted that enhanced flexibility is provided by supporting definition of component attributes by a user. The user may also create appropriate predefined attribute values and constraints for attribute values.

Examples of attributes that can be specified in step 604 include identifying attributes, physical attributes, electrical and connection attributes and status attributes. Identifying attributes include, for example, manufacturer's name, manufacturer's model number, service provider's identifier, bar code identifier, manufacturer's part number, manufacturer's description, face label, equipment class code and equipment subclass code.

Physical attributes generally include height, width, depth, and weight. Typical electrical attributes include voltage type, a voltage quantity, current and current quantity. Further, in a preferred embodiment, additional data fields are included that indicate whether or not the attributes have been completely specified.

In step 606, the user specifies a unique identifier for the newly created component. Next, step 608 indicates the component is stored in product catalog 126.

The process ends with step 610.

B. Creating a Shelf Configuration

FIG. 4A is a flowchart depicting a process that can be used to create a shelf configuration, according to a preferred embodiment of the present invention. Specifically, this process is performed by rackface tool 112, according to a preferred embodiment of the present invention.

The process begins with step 401. In step 404, the user specifies a unique name for the new shelf configuration. Typically, this name must be unique in database 108. In addition, values are specified for required fields. For example, in a preferred embodiment, required fields include a manufacturer, an equipment class and an equipment subclass. Note that in a preferred embodiment, a value for manufacturer or “generic” is used for generic racks as previously described.

Next, in step 406, a pick list comprising a list of predefined components from product catalog 126 is displayed to the user. Thus, components that have been created according to the process depicted in **FIG. 6** are listed in step 406.

Specifically, in this example, a list of shelf components is presented to the user. In a preferred embodiment, sort, find and filter options are provided to assist the user in finding a particular component listed in product catalog 126. In any case, the user is prompted to select a particular shelf from the pick list presented in step 406.

Next, as step 408 indicates, if a desired shelf cannot be found in product catalog 126, control passes to step 410. This can occur for example, if a user desires to use a particular shelf that has not yet been created via the data entry process depicted in **FIG. 6**. Accordingly, the user has the option to create a new product catalog component as indicated by step 410. Process steps that can be used to create a product catalog component 410 are presented in **FIG. 6**, as previously described.

On the other hand, as indicated by step 408, if the pick list in step 406

contains the desired shelf component, the user selects the shelf component in step 412. Control then passes to step 418. In step 418, the user adds modules to the selected shelf.

5 C. Adding Modules to a Shelf

A process that can be used to add modules to a selected shelf is presented in FIG. 4B. The process begins with step 420. In step 420 the user is presented with a pick list that contains a list of predefined modules from product catalog 126. In a preferred embodiment, sort, find and filter options are provided to assist the user in finding a particular module from product catalog 126. Examples of predefined module types include circuit cards 214, computer terminals 210, and other equipment, such as modem 206. Modules are components that are generally installed on shelves 208.

15 As step 422 indicates, if the desired module is included in the list presented in step 420 control passes to step 424, where the user selects the module. If not, once again the user has the option to create a product catalog component, as indicated by step 410.

20 After a module has been selected in step 424, control passes to step 426. In step 426, the selected module is placed in the first available slot 208 on the configured shelf 204. Next, as step 428 indicates, the user is presented with a graphical representation of the shelf and the module as selected from steps 412 and 424, respectively. Control then passes to step 430. In step 430, the user has the option to modify the shelf. As step 434 indicates, this includes for example, adding, moving and deleting modules. In addition, the user can list information about the configured shelf. As indicated by step 434, if the user chooses to add more modules to the shelf, control passes to step 420, and steps 420-430 are repeated.

30 As stated above, in a preferred embodiment, users edit a configured shelf in step 434 by directly manipulating graphical representations of the selected modules from step 428. For example, in one implementation, users “drag” graphical representations of the selected modules to particular locations within the graphical

representation of the selected shelf. Preferably, a mouse or other pointing device is used to accomplish this task.

After the user has completed modifying the shelf, control passes to step 438.

5 In step 438, the configured shelf is stored in configuration library 128, and the process ends at step 440. In a preferred embodiment, the user also has the option to store the shelf as a "work-in-progress" to be completed later. In addition, other status such as "pending approval," "standard," or "special" can be specified. Preferably, only configured shelves with a status of "approved standard" (i.e., standard
10 configured shelves that have been approved) or "special" can be used in a configured rack. After one or more shelves have been configured and stored in the configuration library 128, according to the process in FIG. 4A, the configured shelves can be used to create configured racks.

15 D. Creating a Configured Rack

FIG. 5 is a flowchart illustrating a process that can be used to create a configured rack according to a preferred embodiment of the present invention. The process begins with step 501. In step 501, the user specifies a name for the configured rack. In addition, required fields such as a description, a manufacturer,
20 a class and a subclass are preferably specified in step 501. In step 502, a list of predefined rails from product catalog 126 is presented to the user. In a preferred embodiment, sort, find and filter options are provided to assist the user in finding a particular rail within product catalog 126. In any case, the user is prompted to select a rail from the pick list presented in step 502. As step 504 indicates, if the desired
25 rail is included in the list presented in step 504, control passes to step 506, where the user selects the rail. If not, once again the user has the option to create a rail for the product catalog 126 as indicated by step 410.

If a rail is selected in step 506, control passes to step 508. In step 508, the
30 user is presented with a list of the available configured shelves from configuration library 128. In a preferred embodiment, only shelves that are compatible with the selected rail are presented. Further, as previously noted, in a preferred embodiment, only configured shelves having a status of "approved standard" or "special" will be

presented in the list in step 508. Note that the configured shelves presented in the pick list in step 508 are shelves that have been configured according to the process depicted in FIGS. 4A and 4B, as previously described. In step 510, the user selects a configured shelf from the pick list presented in step 508.

In step 512, a graphical representation of the selected shelf and rail is presented to the user. This graphical representation is presented to allow the user to directly manipulate and modify the configured rack as described below with reference to step 518. In step 514, the user has the option to modify the rack. As step 518 indicates, this includes for example, adding, moving and deleting shelves. In addition, the user can list information about the configured rack. As indicated by step 518, if the user wishes to add additional shelves to the rack, control passes to step 508, and steps 508-514 are repeated.

As stated above, in a preferred embodiment, users modify a configured rack in step 518 by directly manipulating the graphical representations of the selected shelves from step 512. For example, in one implementation, users "drag" graphical representations of the selected shelves to particular locations within the graphical representation of the selected rail. After racks have been configured, for example, by using the process depicted by the flowchart in FIG. 5, the racks can be placed within a site. The explanation of how an environment hierarchy (e.g., a site hierarchy) is built and how graphical objects (such as racks) are placed within the environmental hierarchy is presented in sections VIII and X below.

VII. Database

A. Overall View of the Database

FIG. 10A is a block diagram illustrating a plurality of database tables that can be used to implement database 108 in a telecommunications application according to a preferred embodiment of the present invention. In this exemplary application of a preferred embodiment, a relational database is used to implement database 108. However, in other embodiments, different types of databases can be used. An expanded version of the block diagram depicted in FIG. 10A is also depicted in FIGS. 10C-10N. FIG. 10B shows how Figs. 10C-10N are related to each other to

form the block diagram depicted in **FIG. 10A**.

B. Remote Sites, Power Plants, Responsible Departments, and States

Referring now to **FIG. 10C**, there are illustrated a number of boxes that each represent a specific database table. Accordingly, each database table comprises the names of specific data fields that are defined for each table according to a preferred embodiment of the present invention. For example, table **1004** represents remote sites in a portion of database **108** referred to above as site hierarchy repository **124**.

In this example, the name of each data field is descriptive of the type of data it represents. For example, the first three data fields in site table **1004** are named **SITE ID**, **SITE_CD** and **SITE_TYP_CD**, respectively. These three data fields hold information related to a site identification number, a site code and a site-type code for each site stored in site table **1004**. As such, for the most part, by reading the descriptive names of the data fields illustrated in **Figs. 10C-10N**, the function and purpose of each data field will be apparent to those skilled in the relevant arts.

Typically, data fields in a relational database **108** are conceptualized as columns in a database table. Likewise, data entries stored therein are conceptualized as rows in a database table. Thus, the term row is used herein to describe a single data entry within a database table. Accordingly, the term row and the term entry are synonymous. For example, a single row (or entry) in the site database table **1004** represents data describing the details of a single remote site. A complete description of the remote site comprises specific values for each of the data fields associated with database table **1004**. However, it is generally not necessary to provide values for every data field associated with a database table. This choice generally depends on each specific implementation of the present invention, which will typically define data fields as being either required or optional.

The lines interconnecting database tables shown in **Figs. 10C-10N** represent relationships among tables. It should be noted that for the most part, the database tables shown in **Figs. 10C-10N** are self-explanatory to those skilled in the relevant art(s). Accordingly, after reading the brief description below and examining **Figs.**

10C-10N, it would be apparent to those skilled in the relevant art(s) how to implement database 108 for various application of SiteVu.

As stated, interconnections between database tables shown in Figs. 10C-10N represent relationships among the tables in database 108. For example, a line 1003 is shown connecting site table 1004 to plant table 1002. In this example, plant table 1002 represents power plants that are installed in each site. The circle at the end of line 1003 represents a one-to-many relationship between the rows of site table 1004 and the rows of plant table 1006. Accordingly, each entry in the site table 1004 may be associated with more than one entry in plant table 1006. In other words, each site may have more than one power plant installed therein.

Tables 1006 and 1008 represents pick list tables for specific data fields within site table 1004. Specifically, pick list tables 1006 are associated with data fields used to define a responsible department and a geographical state for a particular site listed in the table 1004. In this example, pick list tables comprise a list of valid values that are used to fill in particular data fields. A pick list table, such as the pick list table 1008, is used to assist in the data entry process. Typically, a pick list table is associated with one or more data fields. For example, pick list table 1008 is associated with a data field STATE_CD within table 1004 (as depicted by dotted line 1005). Preferably, pick list tables are used during data entry to provide users with a drop-down list box, or the like, comprising textual representations of predefined values that can be specified for the row or rows, associated with the pick list table.

Accordingly, using the example described above, a pick list comprising states containing remote sites is presented to the user during a data entry phase. Preferably, after the user selects an item from the pick list (in this case the name of a state), the associated value is automatically stored in the associated row within the database table. Typically, in such cases, users are restricted to values contained in the pick list tables. That is, for such data fields that have pick lists associated with them, values other than those contained in the pick list maybe considered invalid. However, this choice depends on particular implementations of the present invention.

C. Sites Types, Structures (Buildings), Floors, and Zones

Referring now to **FIG. 10D**, table **1009** is a pick list table associated with the site table **1004** for providing valid values for the data field used to store site types. Table **1010** represents structures or buildings within sites. Typically, each site (represented by a single entry or row in the site table **1004**) comprises multiple buildings that are each represented by a single entry in the building table **1010**. Therefore, building table **1010** typically comprises multiple rows for each row in site table **1004**.

Table **1011** represents floors within structures represented by table **1010**. Typically, floor table **1011** comprises multiple entries for each entry in structure table **1010**. Table **1012** represents floor points for the floors represented by floor table **1010**. This information is used in a preferred embodiment of the present invention for rendering graphical representations of floors, as described above. In one embodiment, each entry in the floor point table **1012** contains the x-y coordinates of a portion of a polygon that is used to graphically represent the associated floor. Typically, floor point table **1012** comprises multiple rows for each entry in floor table **1011**.

Table **1013** represents zones within floors represented by floor table **1011**. Typically, zone table **1013** comprises multiple entries for each entry in floor table **1011**. Table **1014** represents zone points for the zones represented by zone table **1013**. This information is used in a preferred embodiment of the present invention for rendering graphical representations of zones. In one embodiment, each row in zone point table **1014** contains x-y coordinates for a portion of a polygon that is used to graphically represent the associated zone. Typically, zone point table **1014** comprises multiple entries for each entry in zone table **1013**.

D. Planning Units, Rows, and Row Segments

Referring now to **FIG. 10E**, table **1015** represents planning units within zones represented by zone table **1013**. Typically, planning unit table **1015** comprises multiple entries for each entry in zone table **1013**. Table **1016** represents points for planning unit table **1015**. This information is typically used for rendering graphical

representations of planning units. In one embodiment, each row in planning unit point table **1016** contains x-y coordinates for a portion of a polygon that is used to graphically represent the associated planning unit. Typically, planning unit point table **1016** contains multiple entries for each entry in the planning unit table **1015**.

5

Table **1017** represents rows within planning units. Typically, row table **1017** comprises multiple entries for each entry in planning unit table **1015**. Table **1018** represents row segments within rows. Typically, row segment table **1018** comprises multiple entries for each entry in the row table **1017**. As will be shown below, configured racks are placed within row segments.

10

E. Product Catalogs, Shelves, Cards (Modules) and Rails

Referring now to **FIG. 10F**, a number of tables **1019-1023** are depicted that form a portion of database **108** referred to herein as product catalog **126**. Specifically, table **1019** represents components, such as modules, shelves and racks, as previously described. Data fields within the product catalog table **1019** preferably contain detailed information about each component stored therein, such as a part number, a classification, and physical dimensions of the component. In a preferred embodiment, information common to all types of components is stored in product catalog table **1019**, and information specific to predefined component types are stored in database tables **1020-1023**.

15

20

For example, shelf table **1020** represents additional information particular to shelf components, such as the quantity of wire, coaxial and fiber connectors. Card table **1021** represents additional information particular to cards or module components. In this example, information such as actual and nominal electrical and power input and output requirements are stored in shelf table **1020**.

25

Likewise, rail table **1022** represents additional information particular to racks, such as the dimensions of the rack header and rack footer areas. In addition, the HVAC rack table **1023** represents additional information about HVAC (heating, ventilation and air conditioning) racks. In this example, such additional information includes quantities for airflow, BTUs per hour, airflow capacity and coolant

30

specifications.

F. Placement Data for Racks Shelves, and Cards (Modules) and Configuration Racks

5 Tables depicted in **FIGS. 10G, 10H, 10J, and 10K** represent portions of the database **108** referred to herein as configuration library **128** and portions of the database used to store footprint information as described above. Specifically, the portion of database **108** referred to herein as configuration library **128** is primarily represented by configured racks table **1062 (FIG. 10J)** and configured shelves table **1026 (FIG. 10K)**.

10 As shown by interconnecting lines, both the configured racks and the configured shelves table **1062** and **1026**, respectively, are related to product catalog table **1019**. Specifically, as previously stated, configured racks and configured shelves include components (e.g. modules, shelves and racks), from product catalog **1019** that have been interrelated. In a preferred embodiment, the interrelationships for configured racks and shelves are defined utilizing rackface tool **112**.

15 Configured rack item table **1025 (FIG. 10K)** represents individual rack positions used to hold shelves, for each rack defined in configured rack table **1062**.

20 In a preferred embodiment, configured shelves that are installed in particular rack positions are defined by configured shelves table **1026**. Accordingly, each entry in configured shelves table **1026** can correspond with a single entry in configured rack item table **1025**. Note, however, that entries within configured shelves table **1026** can be associated with multiple entries in configured rack item table **1025**. This would be the case, for example, if the same configured shelf is used in multiple rack positions in a single rack or used in multiple racks.

25 Configured shelves item table **1027 (FIG. 10K)** represents individual shelf positions that are used to hold modules for each shelf defined in configured shelves table **1026**. In a preferred embodiment, modules that are installed in particular shelf positions are defined by product catalog table **1019**. Accordingly, each entry in product catalog table **1019** can correspond with an entry in configured shelf item

30

table **1027**. It should be noted, however, that in a preferred embodiment, each entry within product catalog **1019** is typically associated with multiple entries in configured shelf item table **1027**.

5 A particularly novel and advantageous feature of a preferred embodiment of the present invention is provided by placement library **130**. Specifically, placement library **130** contains placement data for racks table **1061** (**FIG 10G**), placement data for cards table **1024** (**FIG. 10H**), and placement data for shelves table **1063** (**FIG. 10H**). Placement data for racks table **1061** is used to place configured racks from
10 configured racks table **1062** in particular row segments within row segment table **1018**. In this example, one or more racks can be placed in a particular row segment. This feature is preferably implemented by creating a footprint using a placement tool **116** as previously described above.

15 Preferably, specific data fields within the placement data for racks table **1061** are used for planning purposes. Such data fields are used to define specific time-related events, such as planned and actual installation, activation, decommission and removal dates. This allows site planners to view data related to the configuration and placement of equipment in remote sites on a time-dependent basis. Moreover, in a
20 preferred embodiment of the present invention such information is provided at the rack, shelf and module level.

As described above, placement data for rack tables **1061** provides such time-dependent data for field equipment at the rack level. Similarly, placement data for
25 shelves table **1063** provides such time-dependent data for field equipment at the shelf level. Likewise, placement data for modules table **1024** provides time-dependent data for field equipment at the module level. Using this feature of the present invention, site planners and other groups can view data related to field sites on a time-dependent basis. Preferably, each card (or module), shelf and rack that is placed
30 within a remote site will have associated planned and actual installation, activation, decommission and removal dates. In this manner, users for example, can view the configuration and placement of equipment within remote field sites at a particular past, present or future date.

G. Additional Pick List Tables

FIG. 10I comprises additional pick list tables from pick list **134** within database **108**. Specifically, vendor information pick list table **1028** comprises valid values used to describe predefined manufacturers. In this example, vendor information pick list table **1028** is associated with product catalog table **1019**, configuration racks table **1062** and the configuration shelves table **1026**. Similarly, class pick list table **1030** is used to store predefined values describing equipment classes. In this example, class pick list table **1030** is associated with the zone table **1013**, configuration shelves table **1026**, configuration racks table **1062**. Likewise, sub-class pick list table **1029** comprises predefined valid values used to describe equipment sub-classes. In this example, sub-class pick list table **1029** is associated with product catalog **1019**, configuration shelves table **1026**, and configuration racks table **1062**. In addition, in this example, pick list tables **1028**, **1029** and **1030** are associated with connection tables **136**, as described below with reference to **FIG. 10L**.

H. Connection Tables

FIG. 10L depicts an embodiment of connection portion **136** of database **108**. Specifically, connection tables **1031-1035** are used to logically or physically connect one database entity with another database entity without providing the details of the connection. For example, connection portion **136** of database **108** can be used to provide a logical connection between a power plant site hierarchy level and a particular footprint that draws power therefrom. In another example, connection portion **136** of the database **108** can be used to provide a physical connection between a main power distribution bay and a particular footprint. Connection tables **1031-1035** are used in a preferred embodiment to define rules for connecting objects within database **108** to one another. For example, connection rules table **1032** defines what types of objects can be connected together. Similarly, the connection rules sub-class table **1036** defines what sub-classes of equipment can be connected together. Connection table **1034** is used to define what objects are connected together.

I. User Security Tables

FIG. 10M illustrates user security tables **1037-1043**, which form user security portion **132** of database **108**. Tables **1037-1043** are preferably used to control database access and the access to specific functions within SiteVu based on user identification. In the depicted embodiment, tables **1037-1043** describe which functions particular users are allowed to performs. For example, in one embodiment, only users with a transmission rating are permitted to place transmission equipment in remote sites. Such control may be implemented with user security tables **1037-1043**. The power tables portion **138** of database **108**, which comprises tables **1044-1052** shown in **FIG. 10N**, are used for power planning as described below.'

VIII. Creating Graphical Objects to Represent Levels of an Environmental Hierarchy

A. Definition of a Footprint

A footprint is the union of an object, such as a configured rack described above, and a specific location on the floor space. In other words, a footprint refers to the space or area occupied by a configured rack at a site. As will become apparent from the discussion presented below, the primary purpose of placement tool **116** is to create a plan, e.g. a five-year plan, that describes a physical and environmental map of configured racks at a given site. The primary product of the placement tool **116** is the placement of footprints on the floor space.

B. The Administrative Tool Function in Establishing a Hierarchy

Referring to **FIG. 1E**, in the preferred embodiment, administrative tool **114** is software written in C++ that runs on a Windows® operating system and uses a Windows Application Programming Interface **115** to implement its functions on workstation **104**. Before the placement of any graphical objects, such as floor graphical objects, zone graphical objects, planning unit graphical objects, row segment graphical objects, and footprint graphical objects, it is necessary to use administrative tool **114** to establish a base site-structure-floor hierarchy in database **108**. In this manner, at least a minimum amount of non-graphical (tabular) information must be established regarding the site-structure-floor hierarchy before any structures can be graphically represented. For example, in one embodiment the

user must name a site (if the site does not exist), name a structure within the site, and name a floor within the structure. Administrative tool **114** (1) creates site table **1004**, structure table **1010**, and floor table **1011** in database **108**, as shown in **FIGS. 10C** and **10D**, and (2) fills in the first fields for these tables, corresponding to the names of the tables, as described in Sections X.A, X.B and X.C. The user can also fill in numerous other database fields, as described in these sections.

In addition, while using administrative tool **114**, the user can associate with a site-structure-floor an accompanying architectural (also known as civil) drawing. An architectural drawing provides the architectural layout of the floor from a plan (top) view, including the existence of columns that support the building, fire escapes, air vents, doorways and other entrances. In addition, the architectural drawings detail the location of power cables and HVAC units. Referring to section X.C.4, the name of the file containing the architectural drawing is stored in floor table **1011**, as shown in **FIG. 10D**.

C. Placement Tool Functional Overview

In the preferred embodiment, placement tool **116** is implemented as application software running on a Windows operating system. In a preferred embodiment, placement tool **116** is implemented using the Microstation Development Language (MDL). MDL is a high-level host language that Microstation incorporates for developing programs that interface with the CADD functions provided by the Microstation CADD program. For example, to allow a user to trace out a floor, or a zone, or some other type of graphical object, placement tool **116** submits a corresponding MDL command to instruct Microstation **117** to allow the user to render a graphical representation of the traced object on the display or other device.

In addition, placement tool **116** comprises software written for interfacing with database **108**. Hence, when a graphical object is created and drawn by Microstation **117**, placement tool **116** can update database **108** with specific information pertaining to the dimensions of the graphical object. For example, when a user creates or updates the graphical representation of a floor, placement tool **116**

creates or updates non-graphical (logical) information in floor points table **1012**, which is described in section X.D and shown in **FIG. 10D**. Therefore, the graphical information is stored in non-graphical (tabular) form, which is used to recreate the graphical representation of that information, so that a user can bring up and modify the floor at a future date.

In addition, placement tool **116** allows the user to add numerous other pieces of information to database **108** that are generally not represented graphically. For example, as discussed in section X.C.6, floor table **1011** (shown in **FIG. 10D**) stores the date the floor object was created, the user who created the floor object, the last user who updated the floor object, and the last date the floor object was updated. As described below, all information in the site hierarchy is readily accessible to the user while using placement tool **116**.

There are also functions performed by the placement tool **116** that combine the function of CADD program **117** and database **108**. For example, when a user uses the mouse to graphically layout a floor, placement tool **116** uses Microstation **117** to calculate the area of the floor and further uses database **108** to store this information. As described in section X.C.5, this information is stored in floor table **1011** as area quantity field **1011f**. The details of placement tool **116** will become more apparent from the detailed discussion below.

D. Creation of Graphical Objects

FIG. 7 is a flowchart illustrating a process that can be used to define the graphical portions of a site hierarchy, according to a preferred embodiment of the present invention. This process is performed by placement tool **116** according to a preferred embodiment of the present invention.

1. Selecting a site

The process begins with step **702**. In step **702**, a user specifies a predefined site. This is preferably accomplished by selecting a site from a pick list of sites that have been defined via the administrative tool **114**. The data related to the site is stored by administrative tool **114** in site hierarchy repository **124** of database **108**.

The data is specifically stored in site table **1004**, as shown in **FIG. 10C** and explained in section X.A.

In should be noted that placement tool **116** can provide a security feature to prevent unauthorized individuals from creating and updating any type of graphical or non-graphical information. For example, when a user desires to add a graphical object to a site and selects a site from the pick list of sites, placement tool **116** can ensure that the user is authorized to access information about the site, for example, by matching a user's department with the department responsible for the site. Use of the security measure is also available for determining whether an individual is authorized to create or update any other level in the hierarchy as well. For example, should a user desire to create a new floor object (as described below), placement tool **116** can require the user to be an authorized facilities planner responsible for creating the initial graphical site hierarchy. The placement tool **116** can also be configured to permit or deny users the ability to use certain functions of the tool. These functions are described below in detail.

2. Selecting a structure

After a site is selected in step **702**, control passes to step **704**. In step **704**, the user specifies a particular building. Again, this is preferably accomplished by having the user select a particular building that corresponds with the particular site selected from step **702**, according to the site hierarchy repository **124**. The data are stored in structure table **1010**, as shown in **FIG. 10D** and explained in section X.B.

3. Selecting a floor

After a building is selected in step **704**, control passes to step **706**. In step **706**, the user selects a particular floor corresponding to the building selected in step **704**. Again, this is preferably accomplished by having the user select a floor that corresponds with the particular building selected from step **704**, according to the site hierarchy repository **124**. The data are specifically stored in floor table **1011**, as shown in **FIG. 10D** and explained in section X.C. Control then passes to step **708**.

4. Displaying an architectural drawing

In a preferred embodiment, as indicated by step 708, the user is presented with a graphical display of an architectural drawing of the floor that is selected in step 706. The architectural drawing is used as a guide to assist the user with creation of the site hierarchy. Preferably, the CADD software (e.g., Microstation 117) renders the architectural drawing of the floor. For example, in a preferred embodiment, after the user selects a particular floor, placement tool 116 reads the name of the architectural drawing from floor plan drawing file name field 1011e, which is a field of floor table 1011, as described in section X.C.4 and shown in FIG. 10D. Placement tool 116 then directs CADD program 117 to display the architectural drawing corresponding with the name fetched from database 108.

It should be noted, however, that the use of architectural drawings as a guide and backdrop is optional. Users can define the floor, zones, planning units, rows and row segment, as described with reference to the steps below, without the use of an architectural drawing. For example, if the structure is a simple shed for storing telecommunications equipment such as light wave regenerators, the use of an architectural drawing may be unnecessary for a facility planner who desires to create a floor object. However, if the structure is a large brick-and-mortar (e.g., conventional building) facility for storing many rows of computing equipment, a facility planner can find the architectural drawing quite helpful. The architectural drawing can provide the facilities planner with necessary information, including the locations of columns that support the building, fire escapes, air vents, doorways and other entrances, power cables for providing electricity, and HVAC units, etc. The architectural drawing is also useful for the facilities planner for "tracing out" a useable floor space, as explained below.

5. Placing a floor object

As step 710 indicates, the user places a floor, which simply means that the user creates the graphical floor object in the site-structure-floor hierarchy. In the preferred embodiment, whether or not the architectural drawing is displayed, the user uses an input device (such as a mouse) to trace out a usable area in the floor space. The user, who is most likely a facilities planner, attempts to maximize the usable

floor space to be allocated for placing equipment, while concurrently determining real-life limiting factors, such as the location of power cables for supplying power to the equipment, supplying sufficient ventilation to equipment, and providing ready human access to the equipment with sufficient entrance ways.

5

When the user traces out the usable space, placement tool **116** directs Microstation CADD **117** to show the floor space to the user graphically. In addition, placement tool **116** stores the traced out floor space in a non-graphical format as a sequence of points in database **108**, specifically in floor points table **1012**, described in section X.D and shown in **FIG. 10D**.

10

Placement tool **116** performs other important functions as well. It directs Microstation CADD **117** to calculate the area of the usable floor space and stores it in database **108**, specifically in the area quantity field **1011f**, described in section X.C.4 and shown in **FIG. 10D**. Placement tool **116** also stores the identification of the user and the date the user created the floor object in database **108**, as described in section X.C.6 and also shown in **FIG. 10D**. Placement tool **116** also provides the user the ability to store additional information regarding the floor object or even to change existing information regarding the floor object, including the remaining fields of floor table **1011**, as described in section X.C.

15

20

6. Placing a zone object

As step **712** indicates, the user places a zone (i.e., places a zone object in the site hierarchy), which is the next level in the hierarchy. Zones provide an important functional distinction between classes of equipment, meaning that a facilities planner can restrict a zone to one class of several possible classes of equipment. The classes available are restricted only by the imagination of the facilities planner. In some applications, a facilities planner may provide very narrowly tailored zones such as restrictions between particular pieces of telecommunications equipment, while in other applications a facilities planner can distinguish between widely tailored classes such as between computer racks and pieces of furniture. At this level, the ability of the facilities planner to provide a proper balance between providing a maximum amount of usable floor space and taking into consideration limiting real-life

25

30

considerations pertaining to the architecture of the building are even more important.

As a crude example, if a facilities planner has to place furniture equipment in furniture equipment zones and functioning processors in processor zones, the planner would be concerned with providing adequate power supplies to the latter and not the former. Consequently, the processor zones can be located within adequate reach of power supply cables. The allowed class of equipment is stored in equipment class code field **1013d** of zone table **1013**, which is described in section X.E.4 and shown in **FIG. 10D**. It should be noted that in a preferred embodiment the class of equipment must be a permitted class, as defined and stored in table **1030 (FIG. 10I)**; otherwise, the class is not permitted.

As with floor objects, the user traces out zones using placement tool **116**, which in turn directs Microstation CADD **117** to display the zones on the display of workstation **104**. Placement tool **116** stores the traced out zone space in a non-graphical format as a sequence of points in database **108**, specifically in zone points table **1014**, described in section X.F and shown in **FIG. 10D**.

Placement tool **116** directs Microstation CADD **117** to calculate the area of the usable zone space and stores the area in database **108**, specifically in the area quantity field **1013e**, described in section X.E.4 and shown in **FIG. 10D**. Placement tool **116** stores the identification of the user and the date the user created the zone object in database **108**, as described in section X.E.6 and also shown in **FIG. 10D**. Placement tool **116** also provides the user the ability to store additional information regarding the zone object or even to change existing information regarding the zone object, including the remaining fields of zone table **1013**, as described in section X.E.

7. Placing a planning unit object

As step **714** indicates, the user places a planning unit (i.e., places a planning unit object in the hierarchy), which is the next level in the hierarchy. In a preferred embodiment, planning units provide the opportunity for more than one facility planner to place row segments in a given zone. In this embodiment, when a user is in the process of defining rows and placing row segments **308**, via the placement tool, other users are prevented from accessing certain portions of site hierarchy repository

124. In particular, when users are defining rows, the site hierarchy level just above the row level must be locked. Thus, a site hierarchy level of planning unit 306 is used between row level 308 and zone level 304. Accordingly, planning unit 306 is locked from other users instead of zone level 304. In this manner, several users can work simultaneously to define row segments 308 within the same zone 304. Planning units are optional, however, and as a result a zone need not contain more than one planning unit.

As with other objects, the user traces out planning units using placement tool 116, which in turn directs Microstation CADD 117 to display the planning units on the display of workstation 104. Placement tool 116 stores the traced out planning unit space in a non-graphical format as a sequence of points in database 108, specifically in the planning unit points table 1016, described in section X.H and shown in FIG. 10E.

Preferably, placement tool 116 is used so that the user can identify the maximum amount of weight a floor can withstand, specifically in the floor load limit quantity field 1015g, described in section X.G and shown in FIG. 10E. In this manner, it is possible to prevent floor damage by preventing the placement of equipment weighing more than a given amount in a planning unit. Placement tool 116 directs Microstation CADD 117 to calculate the area of the planning unit and stores it in database 108, specifically in the area quantity field 1015e, described in section X.G.4 and shown in FIG. 10E. Placement tool 116 stores the identification of the user and the date the user created the planning unit object in database 108, as described in section X.G.6 and also shown in FIG. 10E. Placement tool 116 also provides the user the ability to store additional information regarding the planning unit object or even to change existing information regarding the planning unit object, including the remaining fields of planning unit table 1015, as described in section X.G.

8. Placing a row and row segment object

As step 716 indicates, the user places a row in the hierarchy. A row is a designation of a physical row. Rows are not represented graphically, but are instead

represented logically (non-graphically). The reason for this is that physical rows may be discontinuous because of physical separations between the row, such as support columns. As described in section X.I and shown in **FIG. 10E**, placement tool 116 stores in database 108 an identification for the row, a textual name of the row, which can simply be a number, and information relating to who created the row and when the row was created.

The user can place a row segment object, which is the next level in the graphical hierarchy. The row segment, as its name implies, breaks up the physical row into segments so that one or more row segments comprise a physical row.

As with the other objects, the user traces out row segments using placement tool 116, which in turn directs Microstation CADD 117 to display the row segments on the display of workstation 104. Placement tool 116 stores the traced out row segment space in a non-graphical format as a sequence of points in database 108, specifically in the row segment table 1018, described in section X.J and shown in **FIG. 10E**.

The user can identify, via placement tool 116, the maximum height of equipment placed in a row segment in the height limit quantity field 1018l, described in section X.J and shown in **FIG. 10E**. Placement tool 116 directs Microstation CADD 117 to calculate the length of the row segment and stores it in length quantity field 1018k, which is described in section X.J.7. Placement tool 116 also stores the identification of the user and the date the user created the row segment object in database 108, as described in section X.J.9. Placement tool 116 also provides the user the ability to store additional information regarding the row segment object or even to change existing information regarding the row segment object, including the remaining fields of row segment table 1018, as described in section X.J.

9. Placing a footprint

After the site, structure, floor, zone, planning unit, row and row segments have been established in the hierarchy, the user can place a footprint, which is the union of a piece of physical equipment with floor space. Footprints represent the

lowest level of the site hierarchy and provide the greatest level of detail.

FIG. 8 is a flowchart illustrating a process that can be used for placing footprints, according to a preferred embodiment of the present invention. The process begins with step **802**. In step **804** the user (1) creates a footprint, if a footprint does not already exist, or alternatively (2) updates a footprint, if a footprint already exists. A user can place either a generic footprint or a specific footprint.

A generic footprint is a placeholder for a footprint that will likely later be designated a specific footprint. A generic footprint is a footprint for a configured rack that has an unspecified manufacturer's identification field. For example, the manufacturer's identification field (found in product catalog table **1019**, shown in **FIG. 10F**) for the configured rack (found in configured rack table **1062**, shown in **FIG. 10J**) can be set to "generic." On the other hand, a specific footprint is a footprint for a configured rack that specifies a valid manufacturer's identification field. U.S. Patent No. 6,098,050 referenced above provides a detailed discussion of generic and specific footprints.

Placement tool **116** automatically determines the size of the footprint that Microstation **117** is directed to display. As described below in detail, placement tool **116** provides the user a list of configured racks from which to choose. When a user selects a configured rack that is to be placed, placement tool **116** accesses the configured racks table **1062** (**FIG. 10J**), which in turn accesses other tables (e.g., product catalog table **1019** of **FIG. 10F** and configured shelves table **1026** in **FIG. 10K**) to determine the dimensions of the footprint that is to be placed.

If an existing footprint is being updated, most likely by an individual having placement responsibility at a facility, the user can first fetch all of the graphical objects that are higher in level. For example, the user can select a site, followed by a building (or structure), followed by a floor **302**, followed by a zone **304**, and followed by a planning unit **306**. Placement tool **116** also allows the user to bring up all these levels simultaneously when the user performs a "fetch all" function.

Preferably, the user is provided with an option to display particular site hierarchies or all site hierarchies that are defined for a particular floor. In addition, in a preferred embodiment, once the site hierarchies are graphically displayed, the user can directly zoom-in to a particular portion of the graphical representation and select a particular row therein. Accordingly, the steps of selecting a zone and planning unit, as specified above are effectively bypassed using this method. However, many other methods can also be used without departing from the spirit and principle of the present invention.

In any case, once a particular row is identified, control passes to step 806. In step 806 a build equipment pick list is presented to the user. This pick list comprises a list of configured racks 202, as described above with reference to FIG. 5. The configured racks are stored in the configured racks table 1062 in FIG. 10J and are referenced in rack configuration identification field 1061e, which is described in section X.K.5 and shown in FIG. 10G. In addition, as previously described, generic racks can also be displayed in the equipment pick list. The user selects a rack from the list of racks presented in step 806. Preferably, a configured rack can be a rack holding electrical equipment as particularly laid out in FIG. 2 or instead any other physical object, such as a piece of furniture, as will be appreciated by those of ordinary skill. The user is provided great flexibility in how the configured racks fields are filled out in configured racks table 1062.

Next, in step 808, the user places the selected configured rack from step 806 in a particular location within the row selected in step 804. At this point, placement tool 116 stores the identity of the configured rack in the rack configuration identification field 1061e. Again, this is preferably accomplished by directly manipulating a graphical representation of the rack on top of the graphical representation of the selected row segment.

Once the rack is placed in step 808, control passes to step 810. In step 810 the user specifies particular values for attributes that are associated with footprints. As mentioned, the footprint can be a generic footprint or a manufacturer specific footprint. As described in section X.K and shown in FIG. 10G, there are many fields

that a user can specify for the equipment occupying the footprint, including how the equipment is configured, the envelope of distances surrounding the equipment, and numerous dates. Examples of important dates are when the facilities planners plan to install the equipment, when an individual responsible for installation plans to install the equipment, the actual installation date, when the equipment will be turned on (for equipment requiring a power supply), when the equipment will be decommissioned, etc. Section X.K provides a detailed explanation of the footprint fields in great detail. The user can also update the values in the footprint fields at any time after the values are initially established. The footprint fields can also be viewed or deleted, as described below in further detail.

E. Fetching Objects

After placement tool 116 has directed Microstation 117 to create graphical objects, these objects are stored as non-graphical data in database 108. Any time a user desires to view a previously created object, the user uses the fetch command to view one or more layers of the hierarchy. For example, after identifying the floor (located at a particular building at a particular site), the user can ask placement tool 116 to fetch the floor object, followed by the zone objects, followed by the planning unit objects, followed by the row segment objects, followed by the footprint objects. Here, the placement tool 116 reads the appropriate tabular representation of graphical points from database 108 and uses Microstation 117 to draw the objects on the workstation output device. In one embodiment, the user uses the "fetch all" function to have the placement tool display all of the graphical objects on a floor. As recognized by those of ordinary skill, placement tool 116 can recall the graphical objects in any order, as desired for an application.

F. Deleting Objects

Placement tool 116 permits the user to quickly and easily delete any graphical object, including floor objects, zone objects, planning unit objects, row segment objects, and footprint objects. Placement tool 116 erases the graphical points from the appropriate points tables in database 108 and provides appropriate commands to Microstation CADD 117 to eliminate the on-screen display of an object for the user. In one embodiment, placement tool 116 can prevent a user from deleting a graphical

object if an ancestral graphical object is present. For example, a user can be forbidden from deleting a row segment if a row segment is occupied with footprints.

G. Object Detail

5 Placement tool **116** permits the user to obtain specific details for any object.

As shown throughout section X, there is a tremendous amount of information stored for the objects of the hierarchy (e.g., the hierarchy of site, structure, floor, zone, planning unit, row, row segment, and footprint) in the tables shown in **FIGS. 10C-10E, 10G and 10J**. Much of this information is in the form of tabular (non-graphical) data, which is not necessarily presented graphically, but can have enormous importance to an organization. For example, a user may desire to view the planned installation date for a piece of equipment occupying a given footprint. When a user selects the object detail function, placement tool **116** can immediately read any desired information from database **108** and use Microstation CADD **117** to output the information to the viewer's display. For the above example, placement tool **116** reads planned installation date **1061n** (described in section X.K, and shown in **FIG. 10G**) and displays the information for the user.

H. Object Locate

20 Placement tool **116** permits user to quickly and easily locate objects by keying in on specific information stored as tabular information in database **108**. For example, placement tool **108** can almost instantaneously allow the user to determine all footprints storing a particular type of equipment, such as an M13 multiplexer. When a user selects the object locate function, placement tool **116** can immediately read any desired information from database **108** and use Microstation CADD **117** to show the graphical objects associated with the desired information on the viewer's display. This information can be provided to the user in a report, using the report generator tool **119** shown in **FIG. 1G**.

I. Power Plant Associations

30 Placement tool **116** allows the user to associate a specific source of power, called a power plant, with a footprint. The user can use an input device, such as a mouse, to easily effect the association on the workstation **104**. The main portions of

the above description of footprint placement refers to the placement of “power consuming footprints,” i.e., the placement of footprints of power consuming devices, such as multiplexers, for example. However, placement tool 116 also permits the user to place “power producing” footprints. For example, in one embodiment a describe plant function allows a user to graphically select footprints representing, for example, batteries and rectifiers, for inclusion in a power plant's power producing footprint definition. Since both power producing and power consuming footprints are associated with the power plant definition (plants table 1002 of FIG. 10C), an appropriate power association is established there between.

Plants table 1002 (FIG. 10C) lists the power plants available at a site. Plants table 1002 includes a unique serial number for identification (PLANT_ID), the name of the site associated with the plant (SITE_ID), a name field (PLANT_NM_TXT) that stores a plant name (e.g., “battery_1”), the measured load quantity of power (MSRD_LOAD_QTY) and the minimum reserve quantity of power (MIN_RESV_QTY). Placement tool 116 can read these power plant definitions.

Before a connection can be established between a power plant and a footprint, however, it must be determined whether the desired connection is a valid connection. The connection tables shown in FIG. 10L are used make this determination. Connection table 1034 is used to determine the type of connections between the left object and the right object, which are to be connected together, by determining the connection rules. For example, the left object can be the plant, and the right object can be the footprint. Connection rules table 1032, which has a pointer to the left object type (LEFT_OTP_ID) and a pointer to the right object type (RIGHT_OTP_ID), is used in combination with tables 1033, 1035 and 1036 to determine whether the connection type is allowed. Table 1033 describes the types of connections allowed, including for example physical connections such as power, data, and alarm connections, as well as logical connections. The connection rules sub-class table provides subclasses of object types, such as the subclass of battery type plants. In this manner, placement tool 116 provides a mechanism to check whether the connection is valid.

J. Changing Views

Placement tool 116 permits the user to obtain specific information about objects in graphical form as well. Here, placement tool 116 applies a graphical filter to the objects displayed, specifically applying a graphical filter to the non-graphical information stored in database 108. For example, suppose a user is viewing a floor plan and desires to know which footprints will be occupied by M13 multiplexers five years in the future. After using the fetch object command to locate these footprint graphical objects, placement tool 116 can be used to display only these desired footprints. (When the footprint is created, placement tool 116 can, for example, use footprint date fields 1061m-1061y and footprint identification field 1061a to uniquely distinguish M13 multiplexers existing five years in the future by a specific color.) In this manner, placement tool 116 can provide detail on any graphical object in the hierarchy in a graphical format.

K. Other Microstation functions

For the advanced CADD user, placement tool 116 permits the user direct access to any desired CADD functions, bypassing the more user-friendly functions of the placement tool itself.

IX. Exemplary Implementation of the Invention

The present invention may be implemented using hardware, software or a combination thereof and may be implemented in a computer system or other processing system. In fact, in one embodiment, the invention is directed toward a computer system capable of carrying out the functionality described herein.

An exemplary computer system 901 is shown in FIG. 9. The computer system 901 includes one or more processors, such as processor 904. Processor 904 is connected to a communication bus 902. Various software embodiments are described in terms of this exemplary computer system. After reading this description, it will become apparent to a person skilled in the relevant art how to implement the invention using other computer systems and/or computer architectures.

Computer system 902 also includes a main memory 906, preferably random

access memory (RAM), and can also include a secondary memory 908. The secondary memory 908 can include, for example, a hard disk drive 910 and/or a removable storage drive 912, representing a floppy disk drive, a magnetic tape drive, an optical disk drive, etc. Removable storage drive 912 reads from and/or writes to a removable storage unit 914 in a well-known manner. Removable storage unit 914 represents a floppy disk, magnetic tape, optical disk, etc., which is read by and written to by removable storage drive 912. As will be appreciated, removable storage unit 914 includes a computer usable storage medium having stored therein computer software and/or data.

In alternative embodiments, secondary memory 908 may include other similar means for allowing computer programs or other instructions to be loaded into computer system 901. Such means can include, for example, a removable storage unit 922 and an interface 920. Examples of such can include a program cartridge and cartridge interface (such as that found in video game devices), a removable memory chip (such as an EPROM, or PROM) and associated socket, and other removable storage units 922 and interfaces 920 that allow software and data to be transferred from the removable storage unit 922 to computer system 901.

Computer system 901 can also include a communications interface 924. Communications interface 924 allows software and data to be transferred between computer system 901 and external devices. Examples of communications interface 924 can include a modem, a network interface (such as an Ethernet card), a communications port, a PCMCIA slot and card, etc. Software and data transferred via communications interface 924 are in the form of signals, which can be electronic, electromagnetic, optical or other signals capable of being received by communications interface 924. These signals 926 are provided to communications interface via a channel 928. Channel 928 carries signals 926 and can be implemented using wire or cable, fiber optics, a phone line, a cellular phone link, an RF link and/or other communications channels. In this document, the terms "computer program medium" and "computer usable medium" are used to generally refer to media such as removable storage device 912, a hard disk installed in hard disk drive 910, and signals 926. These computer program products are means for providing software to

computer system **901**.

Computer programs (also called computer control logic) are stored in main memory and/or secondary memory **908**. Computer programs can also be received via communications interface **924**. Such computer programs, when executed, enable computer system **901** to perform the features of the present invention as discussed herein. In particular, the computer programs, when executed, enable processor **904** to perform the features of the present invention. Accordingly, such computer programs represent controllers of the computer system **901**.

In an embodiment where the invention is implemented using software, the software may be stored in a computer program product and loaded into computer system **901** using removable storage drive **912**, hard drive **910** or communications interface **924**. The control logic (software), when executed by the processor **904**, causes processor **904** to perform the functions of the invention as described herein. In another embodiment, the invention is implemented primarily in hardware using, for example, hardware components such as application specific integrated circuits (ASICs). Implementation of the hardware state machine able to perform the functions described herein will be apparent to persons skilled in the relevant art(s).

In yet other embodiments, the invention may be implemented using a combination of both hardware and software.

X. Detailed View of Environmental Hierarchy

In this section, the layers of an exemplary environmental hierarchy from the site down to the footprint (located in database **108**) are described in detail. Database **108** stores non-graphical (logical) data, which are used to interrelate the data tables. These data are also viewable to users in a tabular form. Database **108** also stores graphical data, which is used to illustrate graphically the levels of the hierarchy as shown in **FIG. 3**.

A. Sites

As depicted in **FIG. 10C**, site table **1004** represents a site. A site is the

physical location (e.g., the Dallas-Fort Worth site) where one or more buildings that store equipment, such as racks, are located. Site designates the highest logical layer in the conceptual framework provided by the exemplary environmental hierarchy.

As shown in **FIG. 10C**, sites have the following associated fields.

1. Site identification **1004a** is the unique serial number that identifies a site.
2. Site code **1004b** is a 6-character identification for the site.
3. Site type code **1004c** is a code that identifies the type of the site, as determined by site type table **1009** (**FIG. 10D**). These are the valid types of sites that the system will allow for input into site type code **1004c**. Information cannot be entered for a site unless it is a valid site. Where there is a direct connection from one table into another table, as here, (e.g., site type code **1004c**) the term is referred to as a “foreign key” (FK) into another table.
4. Site name text **1004d** is a name for the site, i.e., for colloquial, every day usage (e.g., the “Dallas-Fort Worth site”).
5. Site short code **1004e** is a three-character site code that provides an alternative method of referring to the site.
6. Responsible department identification **1004f** is a 10-character identification that designates a department responsible for the site. In a large organization, different departments of the organization may be responsible for different sites. This field is a foreign key into the responsible department table **1006**.
7. Physical address lines **1004g**, **1004h**, physical city name **1004i**, physical zip code **1004j**, and physical state code **1004k** are fields used to store the complete address of the site. Physical state code **1004k** is a foreign key into state table **1008**, where valid state codes are stored.
8. Create user identification **1004l**, create date **1004m**, last update identification **1004n**, and last update date **1004o** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

9. Lease code **1004p** identifies whether the site is leased or owned by the organization.

B. Structures

5 As depicted in **FIG. 10D**, structure table **1010** represents a physical structure, which is also referred to herein as a building or a facility. A facility can be a brick-and-mortar building that houses many different types of equipment, or instead a specialized building, such as a telecommunications shelter. As recognized by those of ordinary skill, the function of the structure is not limited by the invention.

10 Examples of specialized structures in the telecommunications industry are a telecommunications shelter used for light wave regeneration, a multiplexer facility, a termination facility where long distance traffic is switched into local telephone network traffic, or a node information center (NIC) housing mainframe computers.

15 Each site can have one or more structures. As shown in **FIG. 10D**, structures have the following associated fields.

1. Structure identification **1010a** is the unique serial number that identifies a structure.
2. Site identification **1010b** is a foreign key back to the parent site associated with the structure. Hence, this field identifies the parent site for the building.
- 20 3. Structure name text **1010c** and descriptive text **1010d** respectively identify and describe the building. Structure name text **1010c** is a name associated with the site, i.e., for common usage. For example, at a certain site, there may be a building dedicated for storing radios, a building dedicated for storing generators, and a building dedicated for storing switches, respectively called "radio," "generator," and "switch." Descriptive text **1010d** describes the building in greater detail.
- 25 4. Create user identification **1010e**, create date **1010f**, last update identification **1010g**, and last update date **1010h** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.
- 30

C. Floor

As depicted in **FIG. 10D**, floor table **1011** is a logical representation of the floors within the facility where the equipment is to be placed. Each structure has one or more floors. As shown in **FIG. 10D**, floors have the following associated fields.

1. Floor identification **1011a** is the unique serial number that identifies a floor.

2. Structure identification **1011b** is a foreign key back to the parent structure associated with the floor. Hence, this field identifies the parent building for the floor.

3. Floor name text **1011c** and descriptive text **1011d** respectively identify and describe the floor. Floor name text **1011c** is a name associated with the particular floor, i.e., for common usage. Typically, the floor name text **1011c** identifies the floor by a number. Descriptive text **1011d** can be used to describe the floor in greater detail.

4. Floor plan drawing file name **1011a** is the name of an optional architectural (civil) file that governs the physical outlay of the floor. The architectural file is produced by a CADD, such as for example Microstation CADD **117**. The architectural file can, for example, represent the locations of fire escapes, physical columns for plumbing, wiring that provide electricity, etc.

5. Area quantity **1011f** is the area associated with the floor. Placement tool **116** allows a user to use a mouse (or other input device) to graphically trace the layout of the floor. When the floor area is traced out, the CADD software or equivalent device can calculate the area associated with the floor in, for example, square inches, and store the information in this field.

6. Create user identification **1011h**, create date **1011i**, last update identification **1011j**, and last update date **1011k** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

D. Floor points

As depicted in **FIG. 10D**, floor points table **1012** is where graphical data regarding the floor are stored. A user can use the SiteVu placement tool application **116** to create a floor object. Placement tool **116** sends a command to Microstation **117** to set up a dialog (or session) with the user. Using the mouse or other input device, the user traces out the shape of the object, which Microstation **117** displays on workstation **104**. When the user is finished the operation, Microstation **117** informs placement tool **116** that the user has completed making a graphical representation of the object. Placement tool **116** then translates the graphical information into non-graphical information, specifically as tabular point data in the floor points table **1012** in database **108**.

When a user later uses the SiteVu placement tool **116** to view a graphical floor object, SiteVu placement tool **116** retrieves non-graphical information (representing the graphical floor objects) from the floor points table **1012** and directs Microstation CADD **117** to draw the floor. As shown in **FIG. 10D**, floor points have the following associated fields.

1. Floor identification **1012a** is a 9-digit unique serial number that identifies the floor.
2. Point sequence number **1012b** is a sequencing number for the points, identifying the order of the sequence of points that make up the floor area.
3. Horizontal coordinate number **1012c** and vertical coordinate number **1012d** are the coordinates of each of the points provided by the CADD software **117**.
4. Create user identification **1012f**, create date **1012g**, last update identification **1012h**, and last update date **1012i** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

E. Zone

As depicted in **FIG. 10D**, zone table **1013** restricts floor space based on an

equipment type, which is also called a class type. For example, if telecommunications switches are identified by the user as an equipment class, then all equipment of the class labeled "telecommunications switch" can be restricted to a "telecommunications switch zone" on the floor. As one of ordinary skill will recognize, zones are limited only by the user's imagination. Examples of zones include collocation zones (where space for equipment owned by other vendors can be leased), furniture zones, multiplexer zones, computer zones, building support (e.g., HVAC) zones, etc. As shown in **FIG. 10D**, zones have the following associated fields.

1. Zone identification **1013a** is the unique serial number that identifies a zone.
2. Floor identification **1013b** is a foreign key back to the parent floor associated with the zone. Hence, this field identifies the parent floor for the zone.
3. Zone name text **1013c** is a name associated with the zone, i.e., for common usage.
4. Equipment class code **1013d** is a foreign key into the class table **1030** (**FIG. 10I**), which identifies the type or class of equipment that can be placed and stored in the zone. For example, a zone can be designated for storage of only switches, only transmission type equipment, only collocation type equipment, or any other type of equipment desired. This feature can be overridden by a user with special access, such as a "superuser." The field makes the zone an intelligent type of container in that a user can predesignate, very specifically, what type of equipment, or more generally, what class of equipment is allowed to be stored within a given zone.
5. Area quantity **1013e** is the area associated with the zone. Placement tool **116** allows a user to use a mouse (or other input device) to graphically trace the outlay of the zone. When the zone area is traced out, the CADD software or equivalent device can calculate the area associated with the zone in, for example, square inches, and store the information in this field.
6. Create user identification **1013g**, create date **1013h**, last update identification **1013i**, and last update date **1013j** are fields that respectively

identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

5 F. Zone points

As depicted in **FIG. 10D**, zone points table **1014** is where graphical data regarding the zone is stored. A user can use the SiteVu placement tool **116** to create a zone object. Placement tool **116** sends a command to Microstation **117** to set up a dialog (or session) with the user. Using the mouse or other input device, the user traces out the shape of the object, which Microstation **117** displays on workstation **104**. When the user is finished the operation, Microstation **117** informs placement tool **116** that the user has completed making a graphical representation of the object. Placement tool **116** then translates the graphical information into non-graphical information, specifically as tabular point data in the zone points table **1014** in database **108**.

When a user later uses the SiteVu placement tool **116** to view a graphical zone object, SiteVu placement tool **116** retrieves non-graphical information (representing the graphical zone objects) from zone points table **1014** and directs Microstation CADD **117** to draw the zone. As shown in **FIG. 10D**, zone points have the following associated fields.

1. Zone identification **1014a** is a 9-digit unique serial number that identifies the zone.
2. Point sequence number **1014b** is a sequencing number for the points, identifying the order of the sequence of points that make up the zone area.
3. Horizontal coordinate number **1014c**, vertical coordinate number **1014d** are the coordinates of the area calculated by the CADD software.
4. Create user identification **1014f**, create date **1014g**, last update identification **1014h**, and last update date **1014i** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

G. Planning unit

As depicted in **FIG. 10E**, planning unit table **1015** logically represents a planning unit. Planning units are divisions within a single zone. Planning units allow for multiple individuals to concurrently place rows, as represented graphically by Microstation CADD tool **117**, into a single zone. The SiteVu placement tool **116** allows a single planner to work in a single planning unit, thereby locking out other planners from the planning unit. As shown in **FIG. 10E**, planning units have the following associated fields.

1. Planning unit identification **1015a** is the unique serial number that identifies a planning unit.
2. Zone identification **1015b** is a foreign key back to the parent zone associated with the planning unit. Hence, this field identifies the parent zone for the planning unit.
3. Planning unit name text **1015c** and descriptive text **1015d** respectively identify and describe the floor. Planning unit name text **1015c** is a name associated with the planning unit, which is a subset of the zone name. Descriptive text **1015d** can be used to describe the floor in greater detail.
4. Area quantity **1015e** is the area associated with the planning unit, which is determined by placement tool **116**.
5. Floor identification **1015f** is a foreign key back to the floor associated with the planning unit. Hence, this field identifies the parent floor for the planning unit.
6. Floor load limit quantity **1015g** indicates the amount of weight (e.g., per square inch) that the floor can withstand in the planning unit.
7. Create user identification **1015i**, create date **1015j**, last update identification **1015k**, and last update date **1015l** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

H. Planning unit points

As depicted in **FIG. 10E**, planning unit points table **1016** is where graphical data regarding the planning unit are stored. A user can use SiteVu placement tool **116** to create a planning unit object. Placement tool **116** sends a command to Microstation **117** to set up a dialog (or session) with the user. Using the mouse or other input device, the user traces out the shape of the object, which Microstation **117** displays on workstation **104**. When the user is finished the operation, Microstation **117** informs placement tool **116** that the user has completed making a graphical representation of the object. Placement tool **116** then translates the graphical information into non-graphical information, specifically as tabular point data in the planning unit points table **1016** in database **108**.

When a user later uses SiteVu placement tool **116** to view a graphical planning unit object, SiteVu placement tool **116** retrieves the non-graphical information (representing the graphical planning unit objects) from planning unit points table **1016** and directs Microstation CADD **117** to draw the planning unit. As shown in **FIG. 10E**, planning unit points have the following associated fields.

1. Planning unit identification **1016a** is a 9-digit unique serial number that identifies the planning unit.
2. Point sequence number **1016b** is a sequencing number for the points, identifying the order of the sequence of points that make up the planning unit area.
3. Horizontal coordinate number **1016c** and vertical coordinate number **1016d** are the coordinates of the area calculated by the CADD software.
4. Create user identification **1016f**, create date **1016g**, last update identification **1016h**, and last update date **1016i** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

I. Rows

As depicted in **FIG. 10E**, rows table **1017** logically represents a physical row

where equipment is to be placed. Physical obstructions can make a row discontinuous, meaning that the row can stop at a column (indicated by an architectural diagram), and continue on the other side of the obstruction. For this reason, the row table is a logical (non-graphical) entity, storing information on the row without providing a graphical object. As shown in **FIG. 10E**, rows have the following associated fields.

1. Row identification **1017a** is the unique serial number that identifies a row.

2. Planning unit identification **1017b** is a foreign key back to the parent planning unit associated with the row. Hence, this field identifies the parent planning unit for the row.

3. Row name text **1015c** is a name associated with the planning unit, i.e., for common usage. The row is typically represented as a number, although it can be identified by a descriptive name, such as the “radio” row, or “switch” row.

4. Create user identification **1017d**, create date **1017e**, last update identification **1017f**, and last update date **1017g** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

J. Row segments

As depicted in **FIG. 10E**, rows segments table **1018** represents graphical information for segments of the rows that are logically represented by row table **1017**. Row segments are provided so that the floor space in a planning unit can be effectively utilized, despite the presence of physical obstructions (such as columns) indicated by an architectural diagram.

As with floor points table **1012**, zone points table **1014**, and planning units points table **1016**, row segment table **1018** comprises graphical data regarding the row segments. A user can use SiteVu placement tool **116** to create a row segment object. Placement tool **116** sends a command to Microstation **117** to set up a dialog

(or session) with the user. Using the mouse or other input device, the user traces out the shape of the object, which Microstation 117 displays on workstation 104. When the user is finished the operation, Microstation 117 informs placement tool 116 that the user has completed making a graphical representation of the object. Placement tool 116 then translates the graphical information into non-graphical information, specifically as tabular point data in row segment table 1018 in database 108.

When a user later uses SiteVu placement tool 116 to view a graphical row segment object, SiteVu placement tool 116 retrieves non-graphical information (representing the graphical row segment objects) from row segment table 1018 and directs Microstation CADD 117 to draw the row segment. As shown in FIG. 10E, row segment points have the following associated fields.

1. Row identification 1018a is a foreign key back to the logical parent, which is the row associated with the row segment. Hence, this field identifies the parent row for the row segment.
2. Row segment sequence number 1018b uniquely identifies the row segment within the parent row, using a 3-digit serialization quantity.
3. Floor identification 1018d is a foreign key back to the floor associated with the ancestor planning unit. Hence, this field identifies the ancestor floor for the row segment.
4. Zone identification 1018e is a foreign key back to the ancestor zone associated with the row segment. Hence, this field identifies the ancestor zone for the row segment.
5. Planning unit identification 1018f is a foreign key back to the ancestor planning unit associated with the row segment. Hence, this field identifies the ancestor planning unit for the row segment.
6. Start horizontal coordinate number 1018g, start vertical coordinate number 1018h, end horizontal coordinate number 1018i, and end vertical coordinate number 1018j are the coordinates of the non-graphical points representing the graphical row segment object to be drawn by the CADD software.
7. Length quantity 1018k identifies the length of the row segment.

8. Height limit quantity **1018l** indicates the greatest possible height of equipment placed in the row segment.

9. Create user identification **1018m**, create date **1018n**, last update identification **1018o**, and last update date **1018p** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and (4) the last date the record was updated.

K. Footprints

As depicted in **FIG. 10G**, placement data for racks table **1061** represent footprints both graphically and logically. In the exemplary embodiment, a footprint is the union of a configured rack, which can be an article of manufacture or a piece of equipment, for example, and a space on the floor, specifically a row segment on the floor. Hence, the footprint refers to a space actually occupied by a piece of equipment in the site hierarchy, containing the most specific and abundant information in the hierarchy.

As per the graphical function, as described in section VIII.D.9 (step **804**) the footprint graphical object is automatically placed once the user selects a row segment graphical object (or creates a row segment graphical object) and selects a configured rack from database **108**. When a user later uses placement tool **116** to retrieve a graphical floor object, placement tool **116** retrieves the appropriate non-graphical information representing the graphical object from database **108** and directs Microstation CADD **117** to draw the footprint object. Logically, the footprint stores a great deal of non-graphical information regarding the equipment placed therein, including relevant dates. Specifically, as shown in **FIG. 10G**, footprints have the following associated fields.

1. Footprint instance identification **1061a** is the unique number that identifies a footprint.

2. Row identification **1061b** is a foreign key back to the parent row associated with the footprint. Hence, this field identifies the parent row for the footprint.

3. Row segment sequence number **1061c** uniquely identifies the row segment within the parent row. Hence, this field identifies the parent row segment for the footprint.

4. Row segment position code **1061d** is a name given to the position within the parent row segment within which the footprint resides.

5. Rack configuration identification **1061e** is a foreign key into configured racks table **1062 (FIG. 10J)**, which identifies the list of configured racks that are available for placement at the footprint. It should be noted that the configured racks need not be limited to storing modules on shelves, especially where footprints are concerned. For example, a piece of furniture can be stored as a configured rack and have its own footprint. SiteVu placement tool **116** can take a configured rack that has already been built and logically attach it to a footprint in a row segment by placing it in this field.

6. Bayface direction indicator **1061f** indicates whether the equipment faces the front or the back of the row.

7. Offset quantity **1061g** is an offset in length from the row segment.

8. Start gap quantity **1061h**, end gap quantity **1061i**, and back gap quantity **1061k** respectively represent the amount of room (in a distance measure) that is to be permitted to the left, to the right, and behind the equipment. This “envelope” provides room for cable, heat dissipation, and other necessities.

9. Back-to-back indicator **1061j** indicates whether the piece of equipment is back-to-back with another piece of equipment in the same footprint.

10. Anchor point quantity **1061** indicates the length from the front of the row segment that the equipment is to be placed. In some circumstances, the equipment is bolted (affixed) to the floor space at this distance from the front of the row segment.

11. Facilities planned installation date **1061m** stores the planned installation date when a generic footprint is to be replaced with a specific footprint as described below.

12. Planned installation date **1061n** stores the date when a configured rack is going to be placed on the floor. When the engineers determine that an actual piece of equipment is to be placed, i.e., a generic footprint is to be replaced with a specific footprint, then this field is stored in the facilities planned installation date field **1061m**. In other words, at the time, rackface tool **112** replaces the facilities planned installation date field **1061m** with planned installation date field **1061n**.

13. Actual installation date **1061o** is the date that the equipment is actually installed onto the floor.

14. Installation project identification **1061p** is the work project for which the equipment is installed.

15. Planned activation date **1061q** is the date when the equipment (i.e., the configured rack) is made functional. For example, for telecommunications equipment, this refers to when traffic flows through the device. For some equipment, this date refers to when the equipment is simply supplied power. For other types of equipment, e.g., a piece of furniture, the equipment is never activated.

16. Actual activation date **1061r** is when the equipment is actually turned on.

17. Planned decommission date **1061s** is when the equipment is planned to be turned off.

18. Actual decommission date **1061t** is when the equipment is actually turned off.

19. Planned removal date **1061u** is when the equipment is to be physically removed from the floor.

20. Actual removal date **1061v** indicates when the equipment is actually physically removed from the floor, such that the floor space is left open.

21. Removal project identification **1061w** is the work project for which the equipment is removed.

22. Create user identification **1061y**, create date **1061z**, last update identification **1061aa**, and last update date **1061bb** are fields that respectively identify (1) the user that entered the record into the database, (2) the date the user inserted the identification, (3) the last user who updated the record, and

(4) the last date the record was updated.

23. Floor identification **1061cc** is a foreign key back to the floor associated with the footprint. Hence, this field identifies the ancestor floor for the footprint.

24. Zone identification **1061dd** is a foreign key back to the ancestor zone associated with the footprint. Hence, this field identifies the ancestor zone for the footprint.

25. Planning unit identification **1061ee** is a foreign key back to the ancestor planning unit associated with the footprint. Hence, this field identifies the ancestor planning unit for the footprint.

XI. Additional Applications of the Present Invention

The foregoing discussion has principally focused on the application of the present invention to site planning and facilities management in the telecommunications industry. However, as noted above in section I, the present invention is not limited to such applications, but is instead broadly applicable to the management of a collection of physical or virtual items in a modeled environment utilizing a hierarchical conceptual framework. Accordingly, the following discussion elaborates on additional applications of the present invention.

As would be expected, in the following discussion some different terms from those used above in the exemplary telecommunications application are employed to describe the various levels within the hierarchical conceptual framework. In particular, instead of a site hierarchy (i.e., site, building, floor, zone, planning unit, row segment, footprint) and a rack hierarchy (i.e., rack, rail, shelf, component), the hierarchical conceptual framework described below includes elements from an environmental hierarchy (of which a site hierarchy is an example), which the user can utilize to define regions of varying sizes within a physical or virtual environment of interest, and an item hierarchy specifying the hierarchical relationships, if any, that can exist between items from the product catalog that are located within the environment.

As will be appreciated by those skilled in the art, an environmental hierarchy can contain any number of environmental levels (EL_1 - EL_M , where $M \geq 2$) that are deemed necessary or convenient to describe the environment of interest. Thus, when the present invention is applied to differing environments, it is expected that differing numbers of environmental levels may be defined. As discussed above, administrative tool 114 and placement tool 116 may be utilized to create and update information describing the environmental hierarchy. Such data are preferably stored in database 108 in tables, where each table contains graphical and non-graphical data describing a respective level of the environment, as discussed above with respect to the site tables, building tables, floor tables, etc., illustrated in **Figs. 10D-10E**.

The item hierarchy can similarly include as many item levels (IL_1 - IL_N , $N \geq 1$) as is deemed necessary or convenient to describe the spatial or logical relationship between items from product catalog 126 that are located within the modeled environment. Each type of item preferably has an associated table within database 108 that records graphical and non-graphical data relevant to that type of item, as discussed above with respect to tables 1020-1023. The user can construct instances of hierarchically configured items utilizing a SiteVu item hierarchy tool, such as the rackface tool 112 described above with reference to **Figs. 1D** and **6**. The resulting configured items are preferably stored in configuration library 128. As discussed above, after creating items in product catalog 126 and hierarchically configured items in configuration library 128, the user can model the environment of interest by placing one or more items at the highest level of the item hierarchy IL_1 at specified locations within the regions defined at the lowest level of the environmental hierarchy EL_M .

Given this introduction, several additional applications of the present invention will now be presented.

A. Retail Store

The SiteVu software of the present invention can advantageously be applied to the design and management of a retail store, such as department store or grocery store. In such an embodiment, the environmental hierarchy may be implemented as

a site hierarchy similar to that utilized in telecommunications applications. For example, in a department store application, the highest environmental level EL_1 may be defined as the building or portion of the building occupied by the department store. Successive environmental levels EL_2 - EL_5 may be defined as floors, departments (e.g., misses, juniors, sportswear, women's shoes, men's suits, housewares, etc.), planning units (e.g., in which goods may be grouped by manufacturer or type), and footprints (e.g., that contain display fixtures, counters, etc.).

The items populating product catalog 126 that may be placed in the environment can include both items for sale (i.e., retail goods such as clothing, housewares, furniture, etc.) and items not for sale (e.g., store fixtures, HVAC equipment and ducting, power cables and equipment, cash registers, dollies, etc.). The number of levels of item hierarchy associated with each type of item in product catalog 126 can be independently defined. Examples of items having multiple hierarchical layers (and therefore having entries in configuration library 128) include a suit (IL_1), which at a second level of item hierarchy (IL_2) may include a coat, a vest and a pair of trousers, or a counter (IL_1), which at one or more lower levels of the item hierarchy may include a display case for goods, a cash register, a machine to remove security tags, etc. As described above, items at IL_1 , the highest level of the item hierarchy, can be united with a footprint (i.e., the lowest level in the environmental hierarchy) utilizing placement tool 116.

Thus, as discussed above, after constructing the environmental hierarchy, product catalog 126, and configuration library 128, a user is able to add items from product catalog 126 and configuration library 128 to particular locations within the environment modeled by the environmental hierarchy to create a graphical and intuitive view of an actual or proposed arrangement of items within the retail store. As described above in section X, each of the elements from the environmental hierarchy and items from product catalog 126 and configuration library 128 placed within the modeled environment have associated graphical and non-graphical data that can be created, stored in database 108, modified, and viewed by the user. These data describe various characteristics of interest that can be utilized not only for site

planning and management, but also, by tracking the placement and movement of merchandise, for inventory control, loss management, sales forecasting, and profit optimization, among other uses.

5 For example, if an HVAC unit is one of the items placed within a modeled retail environment, the associated table in database **108** can be utilized to track installation, repair and planned replacement dates, power requirements, thermal capacity, efficiency rating, operating costs, etc. This information could be used, for example, by a building superintendent to accurately forecast maintenance and
10 operating costs or to schedule selective maintenance and/or replacement of equipment. On the other hand, for items in the modeled environment that represent retail merchandise, the associated data in database **108** may specify a wholesale cost, projected profit margin, actual sale price, date of display, date of sale, associated footprint at time of sale, total number of units, etc. A store manager can periodically
15 utilize report generator **119** or the graphical view filtering described above in section VIII.J to identify how well goods are selling (e.g., to determine a need to cancel orders or order additional merchandise), determine which locations and presentations of goods result in highest gross sales or profit, calculate total profit per square foot, improve loss control, etc.

20 To facilitate entry of data describing an environment and the placement of items within the environment, it is advantageous to employ automation to avoid manually entering each piece of data utilizing a keyboard or mouse of a workstation **104**. In one preferred embodiment, such automation may be provided by a handheld
25 scanner, such as that described in U.S. Patent No. 5,959,275, which is incorporated herein by reference. Using such a scanner, which may communicate with the SiteVu tool running on exemplary computer system **901** via a wireless communication interface **924**, the user may first specify a particular footprint by scanning a corresponding barcode either printed in a hardcopy printout of the floor layout or
30 physically affixed to a display (e.g., hanging rack or shelving system) occupying that footprint. The user can then enter data specifying which goods are located within the specified footprint (or being added to the footprint from a stock room) by scanning the SKU barcodes typically utilized to identify goods. In this manner, a user can

quickly perform the necessary data entry without engaging in the tedious task of manually keying in (or using a pointing device to enter) all of the information.

Also, as customers select goods off the floor for purchase, a scanner is often utilized as an input device to enter into a cash register the SKU barcode identifying the item being sold. This product identification information, which identifies an item being removed from a footprint, can also be provided to the SiteVu software to automatically update database 108 by removing one of the items having that SKU barcode from the modeled environment. In this manner, a real-time view of the goods presented for sale on the floor of the retail store (as well as goods in stock rooms) may be maintained.

As will be appreciated, this technique of data entry is applicable not only to the entry of data describing a retail environment, but also to the entry of numerous other types of data, as is clear from the descriptions of other applications provided below.

B. Warehouse

SiteVu can similarly be applied to a warehouse environment. A typical warehouse environment may include a plurality of rows of storage units (e.g., pallets, fixed or movable racks, refrigeration units) in which goods are temporarily stored.

In an exemplary warehouse application, the highest environmental level EL_1 may be defined as the building or portion of the building occupied by the warehouse. Successive environmental levels EL_2 - EL_5 may be defined as floor, zone (e.g., perishables, durables, etc.), planning unit (e.g., in which goods may be grouped by manufacturer or type), row segment, and footprint (e.g., of a pallet, movable rack, fixed rack, bin, refrigeration unit, etc.).

As with the retail environment, the items populating product catalog 126 and configuration library 128 that may be placed in the modeled environment can include both warehoused items (e.g., wholesale goods) and warehouse fixtures (e.g., rack units, HVAC equipment and ducting, refrigeration units, power cables and

equipment, packaging and loading equipment, etc.). The number of levels in the item hierarchy associated with each type of item can be defined independently. For example, a movable rack unit may be defined at the highest level of the item hierarchy (IL_1), with additional levels of item hierarchy (IL_2 - IL_4) being respectively defined by shelves of the rack unit, bins supported by the shelves, and individual goods in the bins. Two layers of item hierarchy, on the other hand, may be utilized to define a pallet of goods: a pallet at IL_1 and individual goods at IL_2 . As described above, items at IL_1 , the highest level of the item hierarchy, can be united with a footprint (i.e., the lowest level in the environmental hierarchy) utilizing placement tool 116.

As discussed above, after constructing the environmental hierarchy, product catalog 126, and configuration library 128, a user is able to add items from product catalog 126 and configured items from configuration library 128 to particular locations within the modeled warehouse environment (optionally utilizing the scanning technology discussed above) to create a graphical view and associated database representation of an actual or proposed arrangement of a collection of items within the warehouse. The data within database 108 have a number of different uses for warehouse management in addition to site planning. For example, the data within database 108 and the graphical representation thereof can be utilized by humans or robots to identify a location in the warehouse at which to stock incoming items or remove outgoing items while maintaining a real-time inventory of the warehouse. In addition, database 108 may store in association with each warehoused item a date-in and a date-out, which together indicate duration of storage. This information may be utilized to fairly attribute warehousing fees to particular suppliers or retailers.

A specialized "warehouse" environment in which SiteVu may be utilized is a library. A library, at least conceptually, is an information warehouse of an inventory including books, periodicals, microfiche, electronic data, etc. Utilizing the techniques outlined above, SiteVu may be utilized to track the location of inventory lent to subscribers or other institutions, calculate and record fines, manage periodical subscriptions, plan floor layouts (e.g., to avoid exceeding the loading limits of shelving units or floors), record sources of rare materials, and many other uses.

SiteVu may similarly be applied to other specialized "warehouse" environments such as police impound and towing yards for holding automobiles.

C. Offshore Platform

Another environment to which the SiteVu tool of the present invention may advantageously be applied is an offshore drilling or production platform. On offshore platforms, space is at a premium; accordingly, the SiteVu tool of the present invention can be utilized to perform both "floor" planning and vertical space planning (as well as many other functions) utilizing the principles set forth above.

The environmental hierarchy in platform applications can have at EL₁ the platform itself, with various types of platforms (e.g., fixed, floating, jack-up, etc.) being selectable from a picklist. Lower levels of the environmental hierarchy (i.e., EL₂-EL_M) can be defined as decks, bays, zones, row segments, footprints, etc., as is convenient. The items defined in product catalog 126 that can be placed in the modeled environment can include permanent and semi-permanent fixtures, such as generators and motors, a control room, living quarters, galley, piping, compressors, separators, etc., as well as movable equipment such as drill pipe, drill bits, down hole tools, drill rigs, work over equipment, etc.

The data in database 108 associated with the items from product catalog 126 that are placed within the modeled environment can be utilized in a number of ways. First, as noted above, the data may be utilized for floor and vertical space planning and design. Second, equipment managers can track scheduling and availability data for movable equipment such as downhole tools, workover equipment, platform rigs, test separators, and so on. The scheduling data for movable equipment may include, for example, request date, planned use date(s), in use indication, expected date of completion, and cumulative time in service. Third, for movable equipment as well as more permanent fixtures, it may also be helpful to track scheduling and completion of preventive maintenance and servicing (e.g., for separators, valves, motors and power generators) or safety inspections (e.g., ultrasonic testing of pipes for wall thickness). Fourth, data maintained in database 108 can be utilized to track dimensions of both movable and non-movable equipment placed in the modeled

platform such as drill pipe, conductors on the production deck through which drilling is performed, tubing, casing, etc. This dimensional data can be accessed, for example, by on-shore drilling engineers to determine whether equipment required for upcoming procedures is available on the platform.

5

As will be appreciated from the foregoing, SiteVu has similar applicability to petroleum refineries, chemical processing plants, oil field services organizations and the like.

10

D. Manufacturing, Processing, and Power Plants

15

20

SiteVu can also be advantageously applied to the design, planning, and operation of manufacturing plants (e.g., aircraft or automobile), processing plants (e.g., ore, food or beverage processing) and power generation and transmission plants. In such environments, as with many of the other applications of SiteVu, optimization of the placement of tools, equipment and parts in the finite amount of available space in the plant environment is an important advantage of the present invention. As described above, SiteVu database 108 can also be utilized to conveniently record and display information about plant infrastructure and production equipment such as installation date, service and maintenance scheduling and history, scheduled replacement date, equipment sizes and capacities, etc. This information can be utilized, for example, not only by maintenance and engineering personnel, but also by financial and accounting personnel needing to compute depreciation on fixed assets, cost estimation, etc.

25

30

In addition, SiteVu can be utilized to track the incorporation of component parts into an assembled product. For example, in the context of aircraft manufacturer, multiple aircraft are typically in production concurrently. Each of these aircraft can be represented in configuration library 128 of SiteVu database 108 by a corresponding "generic" aircraft object at the highest level of the item hierarchy (IL₁) that can be placed at a particular footprint on the production floor. Similarly, generic objects representing other important components such as wings, engines, tails, avionics, etc., can be placed at other footprints at which these major components are pre-assembled. Then, as each component occupying a lower level of the item

hierarchy (i.e., IL_2 - IL_N) is assembled with a component at a higher level of the item hierarchy (i.e., IL_1 - IL_{N-1}), details regarding the component and its installation can be tracked in SiteVu database 108.

5 For example, a wing, which may be defined as an item at item hierarchy level IL_2 , may have a number of component systems, such as engines, flaps, lights and deicers, modeled at lower levels of the item hierarchy. As these components are added to the wing, a wing table within database 108 can be linked via pointers (referred to above as a "foreign keys") to other tables in database 108 that each
10 describe a respective one of the installed components. Each of the tables representing a component can detail such information as the manufacturer, assembly information (e.g., planned assembly date, actual assembly date, employee ID of assembler), and quality control verification. Thus, with SiteVu a user can readily obtain very detailed information about an assembled or partially assembled aircraft by selecting graphical
15 objects representing various components of interest, which causes SiteVu to display non-graphical data associated with the objects, as detailed above. In addition, by requesting reports summarizing actual and planned assembly dates from report generator 119, a project manager can readily detect, project and address production delays on the aircraft assembly or portions thereof.

E. Construction

As will be appreciated upon reference to the foregoing description of the application of SiteVu to manufacturing, SiteVu can also be applied to the design, planning, and construction of buildings and other structures (e.g., office complexes,
25 malls, bridges, dams, hospitals, airports, housing developments, spacecraft, etc.).

In construction applications, it is typical that the highest level of the environmental hierarchy (EL_1) represents the parcel of land on which construction will occur, the second level of the environmental hierarchy (EL_2) represents various
30 subdivisions of the parcel, the third level EL_3 represents construction site(s) within the subdivisions, and so on until the lowest level of the environmental hierarchy (EL_M) is reached. As noted above, electronic data files, such as CADD files containing architectural drawings and electronic governmental deed records, can be

utilized to provide graphical and non-graphical data to the SiteVu tool to facilitate accurate development of the environmental hierarchy. Importantly, the tabular data within database 108 associated with the various objects in the environmental hierarchy can include not only dimensional information (e.g., a legal description of the parcel and/or dimensions of buildings), but also additional information, such as the location of easements and utilities, applicable building codes (e.g., setback requirements), and environmental protection information (e.g., required protective measures, use restrictions, and required remediation). In this manner, a user can determine all information relevant to the construction site through an intuitive graphical interface.

The items defined in product catalog 126 and configuration library 128 can represent construction equipment (e.g., bulldozers, cranes, on-site trailers, etc.) and construction materials (e.g., rebar, masonry, bridge supports, HVAC equipment, building fixtures, landscape plants and materials, etc.), as well as one or more structures to be constructed and their component parts. For example, a building may be defined as one of the items at the highest level in the item hierarchy (IL_1) that can be united with the lowest level of the environmental hierarchy (EL_M). Successively lower levels of the item hierarchy can be utilized to represent building wings, floors, suites, rooms, fixtures, etc. The tabular data in database 108 associated with these items can include dimensions, weight/mass, projected construction/installation date, man-hours or hours required to perform construction/installation, cost, and other information of interest.

With the SiteVu tool applied in this manner, a construction firm can not only prepare a detailed proposal for a construction project that includes cost, time, staffing and materials estimates, but also can track construction progress and scheduling as described above with respect to the manufacturing environment. In this manner, the construction management firm can anticipate delays, improve scheduling of subcontractors and materials delivery, verify that loading limitations are not exceeded by requesting appropriate reports from report generator 119, track damaged goods and equipment, record change orders, and perform many other useful functions utilizing a single software tool.

F. Staffing and Provisioning

In some environments to which SiteVu is applicable, staffing and provisioning are important concerns. For example, in a health care facility or amusement park, it may be crucial for safety or efficient operation that different locations within the facility have appropriate equipment or provisions and/or appropriate staffing.

SiteVu can be applied to such environments to ensure adequate provisioning and/or staffing. For example, to efficiently provision a new hospital (the construction of which may be managed utilizing SiteVu as discussed above), certain equipment and/or personnel may be associated with selected levels of the environmental or item hierarchy. Assume that hospital policy (or government regulation) requires that each floor be equipped with two external cardiac defibrillators, each patient room have a thermometer and sphygmomanometer, and that the cardiac care unit (CCU) be staffed with at least ten nurses. If, for instance, successively lower levels of the environmental or item hierarchy describing the hospital are utilized to represent a building, wing, floor, unit, and room, a user can utilize placement tool 116 to place at least two objects representing cardiac defibrillators within one or more rooms of each floor and to place thermometers and sphygmomanometer in each room designated by an attribute in database 108 as a patient room. The tabular data within database 108 associated with each of these objects preferably has a "present" field indicating whether or not the item is inventoried as being physically present at the designated location. In this manner, a report by report generator 119 or graphical view based upon the value of the "present" field can be generated to ascertain the additional equipment needed, if any. Of course, as equipment is moved or removed, database 108 is preferably updated so that an accurate picture of available equipment is given.

Staffing levels may similarly be managed by defining personnel as objects within product catalog 126 and placing graphical objects representing personnel at appropriate locations within the modeled environment. Staffing levels can be monitored in real time by providing inputs to SiteVu from an electronic time stamp

system to monitor the arrival and departure of employees. In addition, prospective staffing levels may be projected through defining calendaring fields in the tables within database **108** associated with each personnel object. The calendaring fields can specify each date (and, if appropriate, hours) for which a person is needed at the associated location and the employee name(s) or ID(s) scheduled to staff each such date. Thus, an employer can ensure adequate staffing (and project hiring needs) by recording in the calendaring fields in database **108** the work schedules of employees assigned to the various staff positions. This is particularly useful in situations in which multiple part-time or seasonal employees are utilized to fill individual staff positions.

G. Waste Removal

In remediation of hazardous waste sites, such as Superfund cleanup sites, offshore oil spills, or buildings having asbestos tiles, the cleanup process typically entails developing a cleanup strategy for the site and then tracking progress as waste is removed and remediation activities are performed. SiteVu is an ideal tool for both development of a cleanup strategy and tracking removal or cleanup of hazardous waste.

When SiteVu is applied to hazardous waste removal, the environmental hierarchy may be implemented as a site hierarchy similar to that utilized in telecommunications applications. For example, the highest environmental level EL_1 may be defined to represent a cleanup site, and the second highest environment level EL_2 may be utilized to define equal area tracts of land, which may conveniently be arranged in a grid. Lower levels of the environmental hierarchy EL_3 - EL_M may be utilized to represent specific treatment areas in the tracts. Of course, if the hazardous waste site includes buildings or other structures, natural subdivisions of the structures (e.g., floor, room, etc.) may also be defined in the environmental hierarchy.

The items populating product catalog **126** that may be placed in the modeled environment can include waste to be removed (e.g., crude oil, lead-acid batteries, asbestos or contaminated soil) and equipment (e.g., earth moving machinery) or personnel utilized to perform the waste removal. As described above, items at IL_1 ,

the highest level of the item hierarchy, can be united with the lowest level of the environmental hierarchy utilizing placement tool 116.

As described above, each of the levels of the environmental hierarchy and items from product catalog 126 placed within the modeled environment have associated graphical and non-graphical data that can be created, stored in database 108, modified, and viewed by the user. These data describe various characteristics of interest such as the type of waste, associated safety precautions, governmental regulations governing the handling and disposal of the waste, waste removal date, remediation measures, and estimated removal time. By requesting reports from report generator 119 and/or filtered graphical views based upon selected data within database 108, a logical waste removal plan including cost and time estimates can be developed, and progress toward remediation can be tracked.

H. Agriculture/Logging

SiteVu can also be utilized to great advantage in the management of resources such as farmland, crops, timber, and livestock. In such applications, the levels in the environmental hierarchy can be utilized, for example, to represent a regional operation (e.g., the north Texas operation) at EL₁, various tracts of land belonging to the regional operation at EL₂, and footprints of plantings or structures (e.g., barns, silos, etc.) within the tracts at EL₃. The tabular data within database 108 associated with the various levels of the environmental hierarchy can indicate legal descriptions of the property, whether the property is leased or owned, rents (if leased), previous yields (e.g., bushels, board-feet, or pounds of meat per acre), current and previous usage (e.g., type of planting and number of years planted, type of livestock and duration of grazing, etc.), land use incentives (e.g., tax and subsidy information) and other pertinent information.

As will be appreciated, the items in product catalog 126 that may be graphically placed in the environment modeled utilizing the environmental hierarchy can include standing or harvested crops, livestock, farming equipment (e.g., trucks, combines, tractors, etc.), and structures (e.g., silos, barns, sheds, living quarters and processing facilities), among others. The tabular data within database 108 associated

with the items in the item hierarchy can include total and current capacities of storage facilities, current and prospective estimated sale price per unit for crops and livestock, maintenance, price and ownership information for farming equipment, and descriptions and schedules of prior and planned cultivation and processing regimens (e.g., the use of fertilizers, insecticides, inoculations, feed supplementation, cutting undergrowth from managed forests, etc.).

Through appropriate use of report generator **119** to generate reports from database **108**, a user can determine optimum times to harvest and sell crops based upon the availability of storage and projected pricing, ensure that crop and grazing rotation plans are followed, analyze yields based on location and/or cultivation regimen, manage use of storage facilities, manage expense and servicing of equipment, etc.

I. Community and Regional Planning

SiteVu may also be utilized in the development, implementation and management of community and regional plans and infrastructure. In community and regional planning (CRP), a governmental entity, for example, a city council or a county commissioner's court, is often tasked with developing and implementing a "smart growth" plan to ensure that future growth is directed in a way that enhances (or at least does not diminish) the quality of life of the community and does not outstrip the growth of infrastructure (e.g., roadways, utilities, public recreation areas, public transportation, school, etc.). Utilizing the techniques outlined above, SiteVu can simplify these tasks.

As an example, an environmental hierarchy can be defined that has as its highest level (EL_1) a geographic region (e.g., a state, county or city) for which a plan is to be developed and has at lower levels (EL_2 - EL_M) logical or governmental subdivisions of the larger geographic region. Each of these levels of the environmental hierarchy preferably has associated tabular and graphical data within database **108**, which may include legal or geographic descriptions, area, current and/or planned uses, current and/or planned development restrictions (e.g., zoning or environmental restrictions), ownership, tax valuation (if privately held), estimated

fair market value for purposes of condemnation and so on.

Items from product catalog 126 that may be graphically and logically placed within areas defined at the lowest level of the environmental hierarchy (EL_M) can represent utilities and the like (e.g., telephone and data cables, gas, water, sewer and power lines, etc.), transportation infrastructure (e.g., sidewalks, bike paths, roadways, rail lines and airports), residential and commercial zones, public parks, schools, cultural centers, government buildings, hospitals, etc. SiteVu database 108 can be utilized to store and display a myriad of useful data associated with these items. Such data may include whether an item presently exists or is planned, planned installation dates, code and zoning compliance for items representing structures, planned and past maintenance dates for utility lines, whether an item complies with a planned use, ownership, distances from city centers, airports, nearest similar item or other locations of interest, etc.

Because SiteVu provides a conceptual framework in which all these data can be logically arranged, viewed (especially on a time-dependent basis), and easily updated, SiteVu is an ideal tool for CRP applications.

J. Data Networks

SiteVu may also be advantageously applied to the design, modeling and maintenance of data networks, including data storage environments. Much like the telecommunications application discussed above, SiteVu can be utilized for space planning and the placement of equipment (e.g., servers, network equipment such as routers and bridges, network interface cards, or disk farms) in particular physical footprints on a floorplan or as components of items so placed. In addition, SiteVu can be utilized to graphically place particular data (e.g., executable software such as SiteVu components 110, 112, 114 and 116 or a database such as database 108), logical drives, and the like within equipment connected to the network. Thus, with SiteVu, a network administrator can easily create, view and modify a model of not only the physical components of the network, but also data and software constructs within the network.

L. Virtual Reality

As a final note, those skilled in the art will appreciate from the foregoing that SiteVu is not limited in application to the modeling of physical environments, but also is also applicable to modeling the two or three-dimensional virtual reality environments and virtual objects located therein. By employing such modeling, for example, in a gaming or simulation context, the effects of time and other variables on items in the virtual environment can be easily and accurately depicted.

For example, in a gaming context, an environmental hierarchy can be defined that has at its highest level (EL_1) an environment representing a simulated structure (e.g., as utilized in many “first person” adventure games) or a simulated geographic region (e.g., as utilized in many role-playing and societal simulation games). Depending upon the type of game, lower levels of the environmental hierarchy (EL_2 - EL_M) may be utilized to represent structures, floors of a structure, rooms in a structure, and footprints at which simulated objects may be placed. The items populating product catalog 126 and configuration library 128 that may be placed in the model environment of a “first person” game include articles that may be retrieved by the game’s protagonist, pre-programmed opponents of the protagonist, hazards to the protagonist, etc.

Alternatively, in a simulation context, the highest level (EL_1) of the environmental hierarchy may comprise, for example, a vehicle control station (e.g., aircraft cockpit or automobile dashboard) and the next lower level EL_2 may comprise footprints for individual indicators or controls. Accordingly, the simulated items populating product catalog 126 and configuration library 128 that may be placed in the model environment may include steering and other controls as well gauges and other indicators.

As described above, SiteVu database 108 can be utilized to organize and store useful data associated with the items placed within the modeled environment. For example, the data associated with hazards, opponent, and other items placed within the modeled environment for a “first person” game can indicate the effect of the items on the protagonist’s “health” or abilities. Alternatively, for a simulation, the

data may include a life cycle and/or cost of a component, so that equipment failure and expense over time can be realistically modeled and trainee response to failures and other problem situations can be assessed.

5

XII. Conclusion

While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

10

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
219